ADULT, JUVENILE AND LARVAL FISH POPULATIONS IN THE VICINITY OF THE J. H. CAMPBELL POWER PLANT, EASTERN LAKE MICHIGAN, 1979

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INTRODUCTION

The distribution and abundance of adult, juvenile and larval fish populations under surveillance during 1979 in the vicinity of the J. H. Campbell Plant will be documented in this report. Data, interpretations and conclusions derived will be integrated with information gathered in 1977 (Jude et al. 1978) and 1978 (Jude et al. 1979a). Data from 1977 and 1978 have been used in arriving at decisions regarding the design of the new intake for Unit 3 and in assessing the impact of the plant's Units 1 and 2 on the fish populations of Pigeon Lake and Lake Michigan. Other reports dealing with Pigeon Lake (Jude et al. 1980) and benthos (Winnell and Jude 1980) complement the fisheries studies. With the completion of the 1979 field season, no additional sampling will be performed in Pigeon Lake. For the new Unit 3, 1979 plus the prior 2 yr will act as the preoperational data base against which operational data will be evaluated. In this document, we hope to concentrate on presenting the results of the 1979 field season for both Pigeon Lake and Lake Michigan with addition of data from 1977 and 1978 to strengthen conclusions, point out variations and establish long-term trends which might be expected to continue. Extensive review of the literature, as was done in prior reports, will not be repeated here.

Our intent in designing the sampling scheme used at the Campbell Plant was to establish a spatial and temporal pattern such that all important species and sizes of fish that inhabit the Campbell Plant area were collected. To this end, we incorporated different gear for both adult and juvenile (seines, trawls, gill nets) and larval fish (pelagic net and sled tows). We increased the intensity of our sampling during known times of spawning (June, July, August), a critical period for fish. We also sampled a wide range of areas (beach zone out to 15 m in Lake Michigan) and we sampled during the day and night to ensure that net avoidance was obviated and that day-active and night-active species were collected. Onshore and offshore migrations could also be documented in this manner. In Lake Michigan, the classical treatment vs. reference area experiment was established to assess the future effects of the Unit 1, 2 and 3 discharge at 6 m and the Unit 3 intake at 11.5 m. A reference 6-m station about 3.1 km south has been fished regularly with surface and bottom gill nets, trawls and larval fish nets. Catches have been compared each year to establish whether differences exist between the two areas so that this station on the south transect can act as a valid control. During future years of Unit 3 operation, potential effects can be documented by comparing catches between the two areas.

In Pigeon Lake, similar gear (seines and larval fish nets) were used to sample resident and migratory fishes. Entrainment of larval fish was monitored at the Unit 1 or 2 discharge to get weekly estimates of the number of larval fish passed through the plant with cooling water. In a similar manner, impinged fish were monitored weekly to procure the necessary data to get a yearly estimate of impingement rate. Discussions of each species of fish can then include a comprehensive description of their biology (distribution, movements, spawning, nursery areas) in Pigeon Lake and Lake

Michigan, how abundant they are in each water body and how much of an impact entrainment of their larvae and impingement of adults and juveniles have on respective populations.

The thrust of this report will be on describing patterns of fish abundance and relating them to the impacts of Units 1 and 2. Preoperational data analysis will continue in 1980 for Unit 3 to ensure valid operational comparisons and assist in any intake design questions related to adult fish or fish larvae which may arise.

STUDY AREA

The J. H. Campbell Power Plant is located on the eastern shore of Lake Michigan in Port Sheldon Township (T6N, R6W) Ottawa County, Michigan (Fig. 1). Land immediately surrounding the 3.24-km^2 site is classified as "dune" area and is characterized by high sand dunes and bluffs (U. S. Army Corps of Engineers 1971). Within an 8-km radius of the plant, land is used primarily for agriculture and forestry. The aquatic habitat immediate to the plant exhibits considerable variation.

Situated directly south of the plant is Pigeon Lake, the natural collecting basin for the Pigeon River before it enters Lake Michigan. The drainage area of the Pigeon River (approximately 155 km^2) supplies an average flow of 1.12-1.26 m^3/s to Pigeon Lake (Water Resources Commission 1968). The present power plant water usage of 18.7 m^3/s for cooling condensers causes the natural flow of Pigeon Lake into Lake Michigan to be directed through the plant. Lake Michigan water is thus used to supplement Pigeon Lake water which is then drawn into the plant and discharged (after being heated 9-10 C) by way of a canal approximately 1 km north of the entrance of Lake Michigan to Pigeon Lake. Two stone jetties (366 m long) were constructed at the entrance of Lake Michigan to Pigeon Lake to maintain a passage from Pigeon Lake to Lake Michigan and thus ensure adequate flow of intake water to the plant for Units 1 and 2. During winter months, this channel is kept from icing over by recirculation of discharge water from the plant. Heated water is piped along the north jetty and released into the canal.

The shoreline of Pigeon Lake reflects the general use of the lake as a recreational resource. A public access boat ramp maintained by the Michigan Department of Natural Resources (MDNR), as well as privately owned ramps and docks are used extensively during spring, summer and fall. Undoubtedly, much of the navigational use of Pigeon Lake is due to its confluence with Lake Michigan. The depth of Pigeon Lake (0.3-1.2 m for more than one-third of its area) as well as its extensive aquatic vegetation preclude extensive use by all but shallow-draft vessels. The deepest part of the lake, located in the western portion, is 7.5 m; there is a moderately deep channel (2.1-5.7 m) following the southern shoreline, which accomodates many docking facilities.

Lake surveys conducted by MDNR as well as sporadic newspaper accounts indicate that Pigeon Lake is heavily fished in winter months with notable success. The river connected to Pigeon Lake also sustains a sport fishery. In October 1964, the river and its tributaries were treated to control sea lampreys. Stream surveys conducted by the MDNR in 1969 on Pigeon River (T6N, R15W) indicated populations of brown trout were present.

Sampling during 1979 was continued in the "undisturbed" part of Pigeon Lake which included beach station V and open water station X (Fig. 2). Vegetation was dense at these stations during late spring-autumn, and the bottom type was composed of soft peat (Consumers Power Company 1975). Two additional stations (M and S), influenced by inflowing Lake Michigan water, were also located in Pigeon Lake. Station M (Fig. 2) was approximately 7 m deep and lacked the dense vegetation observed at station X. Due to activities

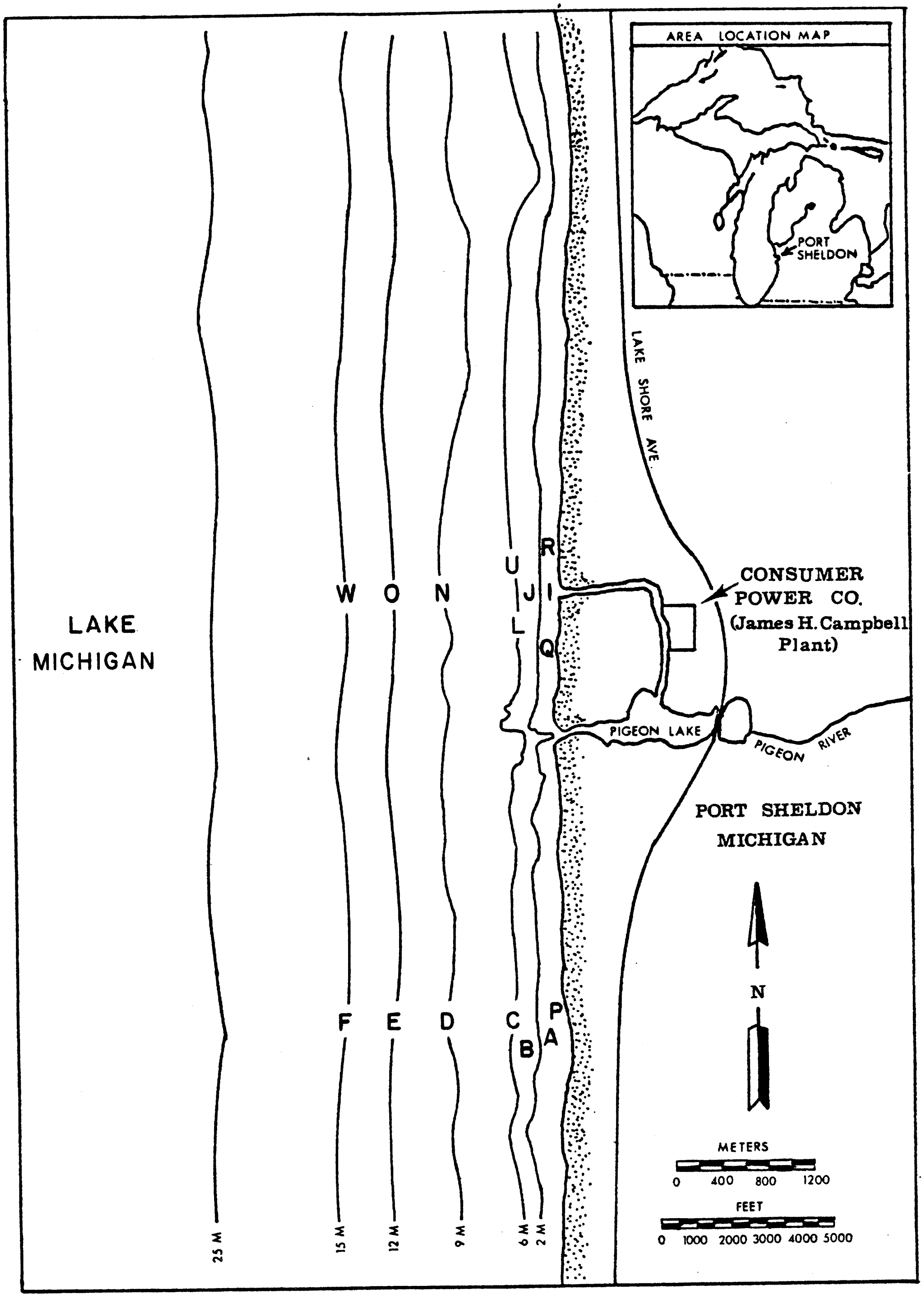


Fig. 1. Scheme of the J. H. Campbell Plant showing Lake Michigan and the 16 sampling stations (A, B, C, D, E, F, I, J, L, N, O, P, Q, R, U and W) established for fisheries monitoring.

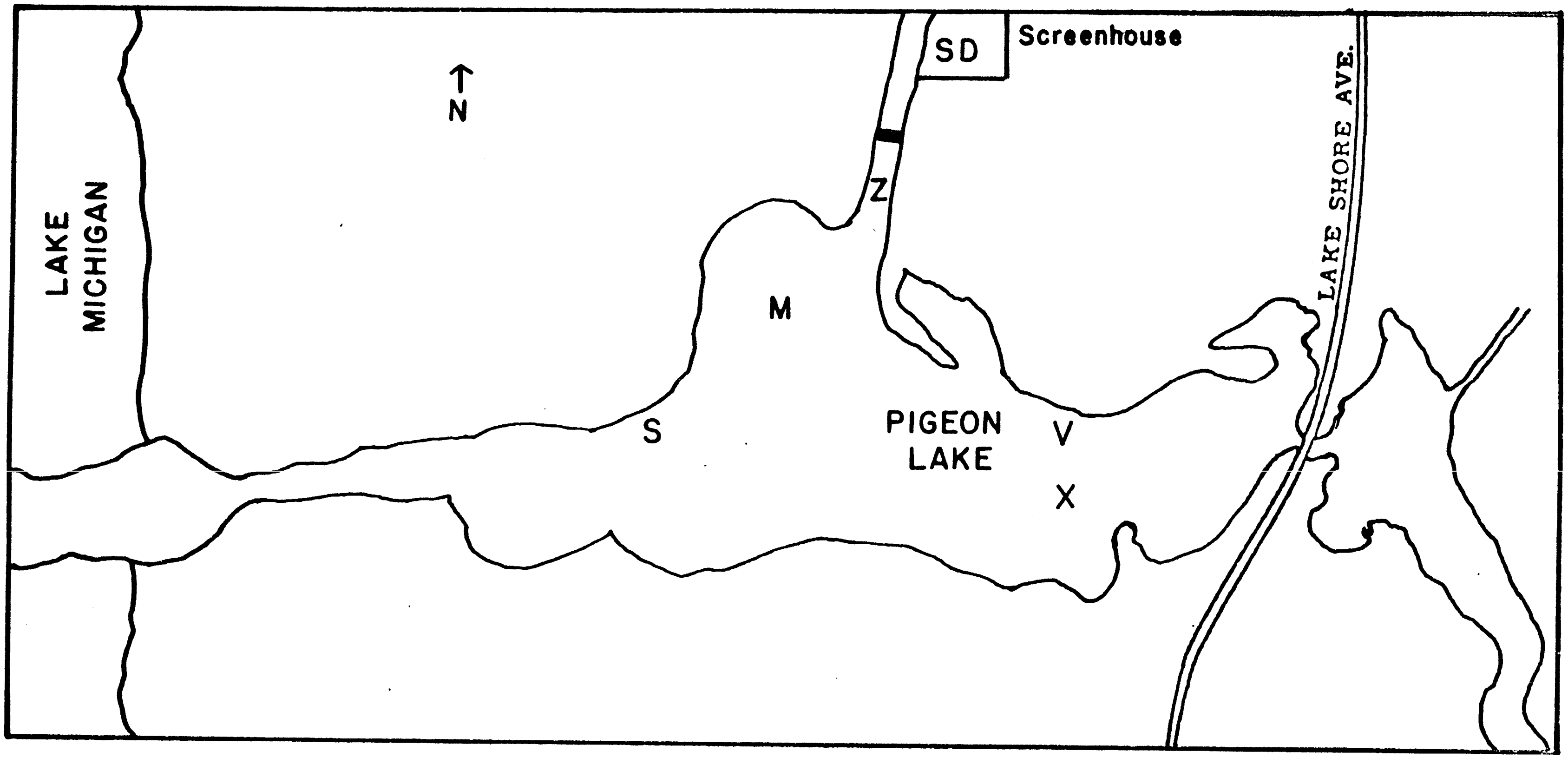


Fig. 2. Scheme of the J. H. Campbell Plant showing Lake Michigan and five sampling stations in Pigeon Lake (M, S, V, X, Z) and the entrainment location (SD) in the discharge canal of the Campbell Plant during 1979.

of Bultema Dock and Dredge Company, gillnetting was discontinued after April at station M. The area designated as beach station S during 1977 (Jude et al. 1978) was relocated in 1978 approximately 100 m further along the Pigeon Lake shoreline toward Lake Michigan (Jude et al. 1979a). This station continued to be sampled in 1979 (Fig. 2). As during 1977 and 1978, this beach station had a fine-sand bottom and steep slope, which restricted the seinable shoreline. In general, characteristics of this station were comparable to its 1977 counterpart with the possible exception of less vegetation at the modified site.

One open water station was located in the intake canal (station Z - Fig. 2) which connects Pigeon Lake with the plant's present (Units 1 and 2) cooling water system. This station was established to monitor numbers of larval fish and eggs just before they are drawn into the power plant. The intake canal is approximately 400 m long and 21 m wide, with a maximum depth of 3 m.

Directly west of the Campbell Plant is the shoreline of Lake Michigan. Again, this water resource finds extensive recreational and navigational use. Fishing in the area of the former onshore discharge canal was popular throughout winter months due to the attraction of fish to the warm water of the discharge area. Lake Michigan depth contours run roughly parallel to shore in the immediate area.

Six stations were chosen at a sequence of depth contours approximately 3.1 km south of the power plant in Lake Michigan (Fig. 1). This reference transect was chosen for its position outside the influence of the present and projected thermal plume and intake channel. Data from these stations are invaluable in describing "normal" trends in fish distribution occurring in Lake Michigan. Stations A - F (south transect) ranged in depth from 1.5 m at station A to 15 m at station F, with intervening stations B, C, D and E separated by 3-m depth intervals.

Seven additional stations were chosen in the area immediate to the present and proposed discharge (Fig. 1). This transect was chosen to monitor fish distribution in the area affected by the present discharge and potentially affected by the proposed discharge. Stations I, J, L, N, O, U and W (north transect) ranged in depth from 1.5 m at station I to 15 m at station W. Two 6-m stations were chosen at this north transect. Station L (6 m), located approximately 0.3 km south of the proposed discharge, and station U (6 m) approximately 0.3 km north of the discharge were chosen to aid in monitoring the projected thermal plume and its effect on pelagic fish movement. Station U will be referred to as 6 m - north discharge throughout the text. Station L will be referenced as 6 m - north, except when referring to surface gill nets when for clarity it will be designated 6 m - south discharge.

Of the three Lake Michigan beach stations established, one (station P - Fig. 1) was chosen in the vicinity of the south open water transect (approximately 3.1 km south of the plant) to act as a reference station in the shoreline area. The two additional stations in the vicinity of the former

onshore discharge canal (station Q approximately 0.6 km south of the discharge and station R approximately 0.6 km north of the discharge - Fig. 1) aid in monitoring the thermal plume and its effect on shoreline fish movements.

Sampling of benthic macroinvertebrates and sediments in Lake Michigan in the vicinity of the J. H. Campbell Plant was also conducted on three dates in 1979: 19 April, 20 July and 16 October. Results are presented in a separate publication (Winnell and Jude 1980).

METHODS

SEINING

Seining was performed using a 0.6-cm (0.25-in) mesh nylon seine, 15.2 m x 1.8 m (50 ft x 6 ft) including a 1.8-m (6-ft) bag. The seine was hauled parallel to shore for a distance of 61 m (200 ft). Duplicate non-overlapping hauls were performed both day and night at all seining stations. Monthly seining was performed from April through November at three beach stations in Lake Michigan and two beach stations in Pigeon Lake (Table 1 and Figs. 1 and 2).

Table 1. Proposed monthly sampling series for adult fish at selected stations in Pigeon Lake and Lake Michigan near the J. H. Campbell Plant, Port Sheldon, Michigan, 1979. X = duplicate sampling (seines, gill nets or trawls).

Station	Maximum Depth (m)	Beach Seining	Surface Gillnetting	Bottom Gillnetting	Bottom Trawling
Pigeon Lake					
M	6.0			X*	
S	1.5	X			
V	1.5	X			
Lake Michigan					
A	1.5			X	
B	3.0			X	X
C	6.0		X	X	X
D	9.0			X	X
E	12.0			X	X
F	15.0				X
U	6.0		X		
L	6.0		X	X	X
N	9.0				X
P	1.5	X			
Q	1.5	X			
R	1.5	X			

* April only. Deleted after equipment was lost to a tugboat in May.

In Lake Michigan hauls were performed against the current when possible. During times when waves and current did not permit seining against the current, hauls were made in the direction of the current. Pigeon Lake stations had very little current, and the direction of seining was southwest to northeast at station V and north to south at station S. Limnological and physical data (water temperature, secchi disc, wind and wave height) were recorded each time a gear was fished.

GILLNETTING

Nylon experimental gill nets 36.6 m x 1.8 m (120 ft x 6 ft) were set once a month for approximately 12 h during daylight and 12 h during the night. Each gill net was composed of 12 panels, with each 3-m long panel starting at 1.3-cm (0.5-in) bar mesh and proceeding in 0.6-cm (0.25-in) increments up to 7.6-cm (3-in) mesh, with the last panel having 10.2-cm (4-in) mesh. Two of these nets fastened end to end were set together and considered replicates. All gill nets were set parallel to shore in Lake Michigan and perpendicular to shore in Pigeon Lake. In Lake Michigan, bottom gill nets were set at the 1.5-, 3-, 6-, 9- and 12-m depth contours on the reference transect 3.1 km south of the plant (also referred to as the south transect) and at the 6-m depth contour opposite the former onshore discharge channel (Table 1 and Fig. 1). Surface gill nets, which are identical to bottom gill nets except for additional floats, were set in Lake Michigan at the 6-m station at the south transect and at two 6-m stations off the former onshore discharge channel.

TRAWLING

Bottom trawling was performed monthly from April through December in Lake Michigan using the University of Michigan's R/V Mysis. All trawls were made at an average speed of 4.8 km/h (3 mph). Duplicate 10-min hauls were performed at the 6-, 9-, 12- and 15-m depth contours on a transect 3.1 m south of the plant and at the 6- and 9-m depth contours between the former onshore discharge channel and the Pigeon Lake entrance to Lake Michigan (Table 1 and Fig. 1). Hauls were performed at 3 m at the south transect during periods of reduced wave height. Trawling was done once during the day and once at night at all stations. A semi-balloon, nylon otter trawl having a 4.9-m (16-ft) headrope and a 5.8-m (19-ft) footrope was used. The body and cod end of the net were composed of 1.9-cm (0.75-in) and 1.6-cm (0.62-in) bar mesh respectively, while the cod end innerliner was 0.63-cm (0.25-in) bar mesh. All trawl hauls were taken parallel to shore following the station depth contour. Two replicate samples were obtained at each station by once trawling south to north and once trawling north to south.

MISSING SAMPLES

The proposed monthly sampling series for Pigeon Lake and Lake Michigan consisted of 28 trawl hauls, 14 duplicate gill net sets (12 excluding station M), 6 duplicate surface gill net sets and 20 beach seine hauls. While it was hoped that proposed fishing could be performed every month, this was not always possible due to inclement weather, accidents or construction activity in the area. Within reasonable time constraints, effort was made to

reschedule sampling which was deleted because of inclement weather. Unfortunately, three samples were lost before they could be examined. For consistency of computer filing programs, these samples were carefully reconstructed from field record sheets which were filled in when samples were collected. Data from fish collected at similar times and locations (replicates) as those in lost samples, were used to reconstruct missing length, weight and sexual condition data. Following is a summary of samples missing from the proposed monthly sampling series in 1979 (number of missing observations in parentheses, reconstructed samples marked by an asterisk):

1. August - impingement sample at SD* (1)

2. November - night surface gill net at L* (1), day and night bottom gill net at A (4), day trawl at B (2)

3. December -impingement sample at SD* (1)

4. April through December - bottom gill nets at M deleted because of tug traffic

IMPINGEMENT

Impingement sampling at the J. H. Campbell Plant was conducted once per week for 24 h from January through December 1979. Four samples covering each 24-h period were designated as follows: day - 0900 to 1700, dusk - 1700 to 2200, night - 2200 to 0500 and dawn - 0500 to 0900. Projected monthly impingement totals were calculated based on weekly samples. An average daily total for our sampling dates each month was determined and then multiplied by the number of days in the month.

Intake screens were washed immediately prior to the beginning of the first sampling period (day). Screens were then washed and samples collected at 1700, 2200, 0500 and 0900 during the period from January to December. Fish were processed in the same manner as fish collected in field samples (see METHODS - LABORATORY ANALYSIS OF JUVENILE AND ADULT FISH).

Condenser cooling water for Campbell Units 1 and 2 is obtained via a 400-m long intake canal extending from the plant to Pigeon Lake. The intake structure is located on the east side of the forebay which is at the north end of the intake channel. Vertical iron trash bars spaced 60 mm (2 3/8 in) apart are located at the face of the screenhouse. The intake screens consist of two Rex Traveling Screens (Rex Chain Belt, Inc.), located in the screenhouse.

Condenser cooling water for Unit 1 is provided by two vertical Peerless pumps (model 66MF) rated at 227 m^3/min (60,000 gpm) at a head of 7.3 m and 290 rpm. Cooling water for Unit 2 is obtained with two vertical Foster-Wheeler pumps (type 60MFA4) which provide 341 m^3/min (90,000 gpm) each at a head of 7 m and 352 rpm.

Fish and debris collected on the traveling screens are removed by rotating and washing the screens with a high-pressure water spray. Fish and debris removed fall into a concrete sluiceway and travel to a central collection basket. The cooling water, after passing through the condensers, is discharged to Lake Michigan via a 1097-m long, 21-m wide discharge canal.

In winter, a warm-water recirculation system pumps warm discharge water to the Pigeon Lake jetties (which extend into Lake Michigan) to prevent ice build-up that can restrict cooling water availability from Lake Michigan. A two-speed pump is employed that carries either 132 m^3/min (35,000 gpm) or 265 m^3/min (70,000 gpm). Pumping normally begins when inlet water temperature drops below 4 C.

FISH LARVAE TOWS

Fish larvae, arbitrarily defined as any fish less than 2.54 cm total length, were collected using a 0.5-m diameter, nylon plankton net of no. 2 mesh (363-micron aperture). Larvae were sampled in Pigeon Lake, Lake Michigan and the intake canal of the Campbell plant. A Rigosha flowmeter (Rigosha and Co. Ltd., 10-4 Kajicho 1-Chome, Chiyoda-Ku, Tokyo, 101 Japan) attached to the center opening of the plankton net was used to calculate volume of water sampled. When flowmeters were not available or stopped functioning, average flowmeter values were computed from readings available from the same stations at other times or from stations of comparable depth. Suspect flowmeter readings were deleted when accuracy was questionable. Out of 1,348 fish larvae samples collected in 1979, 43 either had no flowmeter readings or readings were suspect and required the computation and insertion of an average flowmeter reading. Many of the suspect or lost readings were from samples collected in Pigeon Lake. These stations were choked with aquatic macrophytes during most of the summer making net towing without fouling by plants extremely difficult. Four fish larvae tows were poorly preserved with formaldehyde which resulted in the deterioration of the sample and subsequent loss of information. These samples were: station E - sled tow, 15 May; station F - net tow at 12 m, 15 May; station O - net tow at 6 m, 15 May; station A - sled tow, 22 August. Of the 43 missing readings, 26 were replaced with the other replicate which had an accurate reading. All meter revolutions were converted to volume filtered using 1 revolution = 15 liters. Flowmeters were calibrated in a swimming pool by various personnel walking a measured distance with a flowmeter attached to a 0.5-m diameter hoop without the net (see Jude et al. 1979a).

Duplicate surface tow samples were collected at the seining stations in Lake Michigan (P, Q and R - Fig. 1) and Pigeon Lake (S and V - Fig. 2). Three people simultaneously hand-towed two nets for a distance of approximately 61 m (200 ft) in Lake Michigan and 30 m in Pigeon Lake once during the day and once at night. Beach tows were performed twice in June, July and August and once in April, May and September. Pigeon Lake beach stations were also sampled in October and November.

Horizontal 5-min fish larvae tows were also performed at discrete depths parallel to shore at the remaining 2 stations in Pigeon Lake (M and X), 12 stations in Lake Michigan, (A, B, C, D, E, F, I, J, L, N, O and W) and 1 station (Z) in the intake canal (see Table 2 for actual depths sampled at each station). Open water fish larvae samples were collected from these selected stations in Lake Michigan and Pigeon Lake during the day and night twice in July, twice in August and once in April, May and September.

Larvae tows in Pigeon Lake and the intake canal were collected from a 6-m long outboard motor boat. Open water fish larvae tows in Lake Michigan were collected from the University of Michigan's R/V Mysis as follows:

1) Plankton net with attached mason jar and depressor lowered to desired depth (average ship speed: 3-6 km/h or 2-4 mph)

2) Plankton net towed horizontally for 5 min starting at the desired depth which was obtained by measuring wire angle and trigonometrically calculating the amount of cable to be released to reach desired depth

3) Plankton net hauled to surface and washed using a water hose from the Mysis

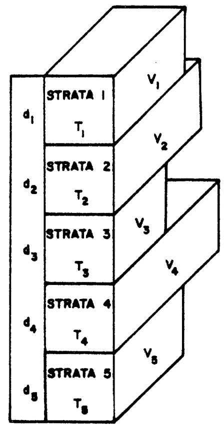
4) Contents rinsed into the wide-mouth glass (0.47 liter) Mason jar, preserved (40 ml of buffered 10% formaldehyde), labeled and sealed

Total numbers of larvae captured in all tows (other than surface tows) were adjusted to compensate for upper strata contamination. The adjustment procedure is outlined in Fig. 3. The method consists of sequential subtraction of numbers of larvae from the lower water depth levels based upon densities observed in upper water strata. We assumed that larvae were homogeneously distributed within a water stratum and that nets passing through a particular stratum from a lower level would catch larvae in proportion to the volume of water filtered. Larvae from all tows conducted below the surface stratum, which were probably caught during the vertical haul following termination of the horizontal tow, were removed via calculation from the final total larvae density presented. We assumed that contamination occurring while lowering the net was negligible. The effect of differential vertical distribution due to larvae size was mitigated by stratifying larvae from each sample into 0.5-mm length intervals. A total of 51 length intervals were defined for fish larvae.

Vertical net hauls, conducted in a 3.6 m deep swimming pool, were used to estimate the volume of water filtered per meter of vertical tow. Mean volume filtered was 0.48 m^3 (28 $\pm$ 0.52 SE revolutions) yielding a correction factor of 0.18 m^3 water filtered/meter of vertical haul. An example of this adjustment procedure is presented in Table 3.

Table 2. Fish larvae sampling depths (m) from selected stations in Pigeon Lake and Lake Michigan near the J. H. Campbell Plant, Port Sheldon, Michigan, 1979.

	Pigeon Lake					Lake Michigan														
Stations:	M	S	V	X	Z	A	B	C	D	E	F	I	J	L	N	O	W	P	Q	R
Tow Depth(s):	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	2.5				2.5		2.5	2.0	2.5	3.0	4.5		2.5	2.0	2.5	3.0	4.5			
	4.5							4.0	4.5	6.0	8.5			4.0	4.5	6.0	8.5			
								5.5	6.5	9.0	11.5			5.5	6.5	9.0	11.5			
									8.5	11.0	14.0				8.5	11.0	14.0			
Maximum Depths:	6.0	1.0	1.0	2.0	3.0	1.5	3.0	6.0	9.0	12.0	15.0	1.5	3.0	6.0	9.0	12.0	15.0	1.0	1.0	1.0
Number of Samples per Period:	6	4	4	4	4	2	4	8	10	10	10	2	4	8	10	10	10	4	4	4



CALCULATION PROCEDURE:

1. Convert current meter reading to volume filtered (V_i)
2. Stratify total larval (T_i) catch for each sample depth interval into n 0.5-mm length intervals, denoted by $N_{i,m}$.

   Thus, $T_i = \sum_{m=1}^{n} N_{i,m}$
3. Calculate average concentration of larvae of length class m in the first stratum for all m.

   Thus, $\bar{C}_{1,m} = (N_{1,m}/V_1)\ 1000$
4. Begin iterative calculation of adjusted average concentrations of larvae for each depth stratum where

$$\bar{C}_{i,m} = \begin{cases} \dfrac{1000\,(N_{i,m} - \mathrm{trc}\ (0.18(\sum_{j=1}^{i-1} d_j\ \bar{C}_{j,m})/1000)}{V_i - 0.18 \sum_{j=1}^{i-1} d_j} = a \text{ if } a > 0 \\ 0 \quad \text{otherwise} \end{cases}$$

where d_i = vertical depth of water in the i-th water stratum

D = total depth of water column $D = \sum_{i=1}^{5} di$

T_i = total uncorrected catch of larvae in the i-th water stratum.

$N_{i,m}$ = total uncorrected catch of larvae of the m-th size class caught in the i-th water stratum.

V_i = estimates volume of water filtered by net towed in stratum i.

(0.18) = correction factor expressed in terms of volume of water filtered/meter of vertical tow.

i.e.,

$$\text{units} = \frac{m^3}{m} = m^2$$

$\mathrm{trc}(\cdot)$ = function which truncates argument to nearest non-negative integer number.

$C_{i,m}$ = adjusted average concentration of larvae of the m-th length class in the j-th depth stratum.

Fig. 3. Schematic representation of adjustment calculations for upper level contamination in larvae samples. Blocks represent varying quantities of water filtered in five different water strata.

Table 3. Example of computational procedures used to correct fish larvae samples for upper level contamination. Refer to Figure 3 for definition of terms. Data values are hypothetical.

Tow depth i (m)	Height of stratum d_i (m)	Volume of water sampled V_i (m^3)	Actual total larvae caught T_i (no.)	Fish larvae length interval m (mm)	Actual number of larvae caught $N_{i,m}$ (no.)	Uncorrected concentration $(N_{i,m}/V_i)\cdot 1000$ (no./1000 m^3)	Corrected concentration $\overline{C}_{i,m}$ (no./1000 m^3)
0	2	30	500	6.6-7.0	200	6666	6666
				10.1-10.5	100	3333	3333
				15.1-15.5	100	3333	3333
				20.6-21.0	100	3333	3333
2	2	25	3	*6.6-7.0	1	40	0
				9.0-9.5	1	40	40
				13.6-14.0	1	40	40
4	2	20	7	7.1-7.5	1	50	51
				8.1-8.5	1	50	51
				*10.1-10.5	2	100	52
				21.1-21.5	1	50	51
				22.0-22.5	2	100	103
6	2	10	12	6.1-6.5	2	200	224
				*6.6-7.0	1	100	0
				*10.1-10.5	3	300	112
				10.6-11.0	2	200	224
				*15.1-15.5	4	400	336
				18.6-19.0	2	200	224
				20.1-20.5	1	100	112

* Adjustment for upper strata contamination performed.

Length-frequency histograms were prepared for various combinations of the larval fish data. Data were presented as a percentage of the total based on densities. Thus, collection of two larvae of different sizes (n = 2) and presentation of these data would not necessarily yield a histogram showing 50%:50%.

SLED TOWS

Bottom tows were performed with a benthic fish larvae sled equipped with a flowmeter (Yocum and Tesar 1980, Jude et al. 1978) (Fig. 4). A single, 5-min sled tow was performed once during the day and once at night at all stations in Lake Michigan when time and weather permitted. Day and night sled tows were conducted coincident with other fish larvae tows at all Lake Michigan stations except station R (north discharge) in April. No sled tows were taken in Pigeon Lake. One sample from the 15 May 1979 sled tow series at station E (12 m - south) was lost due to inadequate sample preservation.

ENTRAINMENT

Design of the entrainment sampling scheme for the Campbell Project was based on previous experience and physical structure of the intake and discharge forebays at the plant. Condenser cooling water for the Campbell Plant is drawn from Pigeon Lake and Lake Michigan via an intake channel connecting the plant's present intake structure and the north shore of Pigeon Lake. After passage through either Unit 1 or Unit 2 condensers, cooling water is discharged to Lake Michigan via a discharge channel approximately 1,100 m long, 21 m wide and 2.1 m deep. Water is heated approximately 9-10 C (Consumers Power Company 1975), then discharged. Weekly entrainment sampling was performed using a net equipped with a flowmeter which was lowered into the condenser discharge canal of either Unit 1 or Unit 2 (contingent upon operation) for 10 min. A heavy weight (18 kg) was necessary to keep the net below the water surface. Four replicates were taken four times during a 24-h period, once at dusk and dawn and once during daylight and darkness. This sampling scheme was followed on a weekly basis from April through September, twice per month in March and October and once per month in January, February, November and December 1979. During the second to fifth weeks of August entrainment sampling was conducted twice a week. During the fourth and fifth weeks only day and night samples were collected. The periods of dawn and dusk were defined as 1 h before and after sunrise and sunset. Sunrise and sunset times were obtained from the Nautical Almanac Office (1979), United States Naval Observatory, Washington, D.C. Daylight and dark hours were calculated also using this information.

Entrainment results were presented as number of fish eggs or larvae entrained per period (four periods per 24 h) derived by the formula:

$$N = D \times V \times T$$

where:

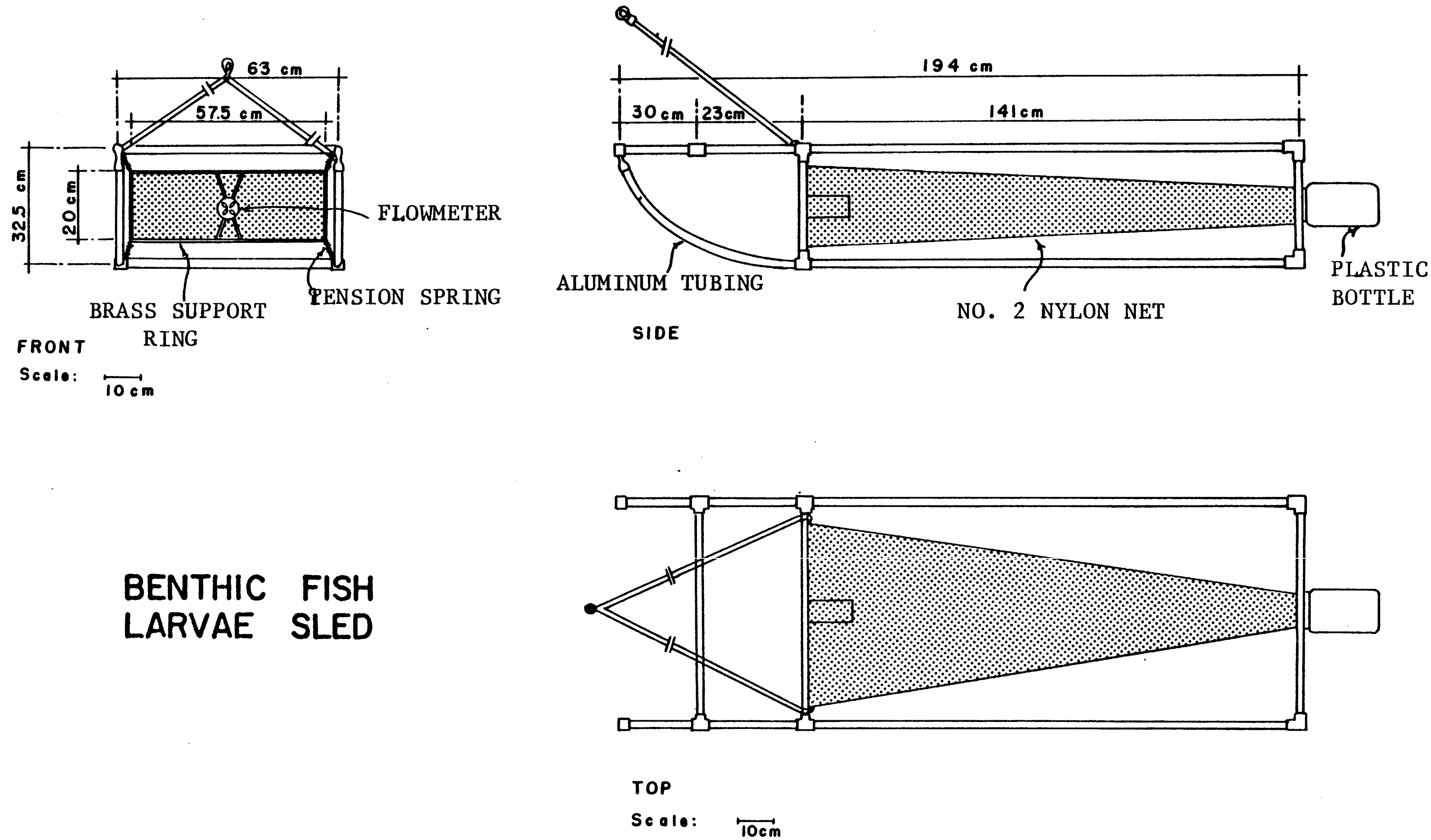


Fig. 4. Benthic fish larvae sled used to collect demersal larval fish. A no. 2, nylon 0.5-m diameter plankton net and Rigosha flowmeter were mounted on the aluminum frame as shown. A pint mason jar, fastened to the net by screwing into a permanently mounted wide mouth jar ring for ease of removal, was inserted into the plastic bottle to prevent damage to the jar.

N = number of fish eggs or larvae entrained per period.

D = mean density of fish eggs or larvae entrained per 1000 m^3 (see METHODS, FISH LARVAE PROCESSING). Sample size per period was four.

V = volume of water in thousands of m^3 pumped per hour by the plant. These values were calculated using plant pumping rates.

T = number of hours of each period at the sampling site located at approximately 43 degrees N latitude. The number of daylight hours was considered to be the period between 1 h after sunrise and 1 h before sunset. The number of hours of darkness was considered to be the period between 1 h after sunset and 1 h before sunrise. The periods of sunrise and sunset were both arbitrarily defined by 2-h duration.

The above calculations were based on the following assumptions:

1) The pumping rate remains constant throughout the 24-h period.

2) The density of eggs or larvae entrained remains the same during each period.

Total estimated entrainment losses for the entire year were calculated for the entrainment section (see RESULTS AND DISCUSSION - YEARLY ENTRAINMENT SUMMARY) in the following manner: the average density (n = 4) of each species and group of larvae collected in each period (day, dusk, night, dawn) was calculated. These densities were multiplied by the amount of water pumped through the plant (based on pump ratings) during that period. The total numbers of entrained larvae from each of the four periods (day, dawn, night, dusk) were then summed to get the total loss for each week. Weekly totals were summed to obtain the yearly estimate.

Of the 637 entrainment samples collected, flowmeter revolutions were not recorded for 5 samples due to clogging or malfunction of the meter. Average weekly values were used in these cases.

Bounds of error were calculated for the numbers of fish larvae and eggs estimated entrained during the year for 1977 through 1979 (See RESULTS AND DISCUSSION - YEARLY ENTRAINMENT SUMMARY). The upper bound of error for an estimate was defined as the estimate plus two standard deviations of the estimate, while the lower bound was the estimate minus two standard deviations of the estimate (the standard deviation is the square root of the variance). Within such bounds we can be confident that at least 75% (and probably closer to 95%) of the estimates generated from repeated sampling will fall within these limits.

The estimated variances for estimates of numbers of larvae entrained during the year were based on the sample variances for each diel period sampled (n=16). Number entrained during 1 wk is not necessarily independent of the number entrained some weeks later. Bounds were adjusted using a

technique developed at the Great Lakes Research Division to account for non-independence among numbers of larvae entrained per 24-h sampling period throughout the year.

Yearly entrainment estimates were extrapolated from larval density estimates derived from our 24-h sampling scheme which was conducted once per week during peak spawning months and less often at other times. To calculate yearly estimates, entrainment rate of larvae from each 24-h sample for each dawn, day, dusk and night period was assigned to a time interval which began at the midpoint between the last sample date and present sample date and ended at the midpoint between the present sample date and the next consecutive sample date. Interval estimates were then calculated based on total flow through the plant during that interval and mean entrainment densities derived for each of the four periods. These estimates were added to give monthly, then yearly total entrainment estimates. The calendar year was not divided exactly in this fashion for the 1978 sampling year in an earlier report (Jude et al. 1979a). To be consistent among years 1977 through 1979, the estimates were recalculated based on the method described above of using exact midpoints between sampling periods (see RESULTS AND DISCUSSION - YEARLY ENTRAINMENT SUMMARY).

It was determined that the estimates of numbers of larvae entrained were accurate to three significant figures based on accuracy of revolution readings (and thus the accuracy of determining volume flow through the net); thus these estimates were presented to three significant figures (see RESULTS AND DISCUSSION - YEARLY ENTRAINMENT SUMMARY). However, throughout the calculation procedure to arrive at the estimates no rounding of numbers was done. Once all estimates were calculated, each one was rounded to a value with three significant figures. Thus, adding up the monthly totals presented in a table for a particular taxon may not yield exactly the annual total number of larvae entrained presented in that table for that particular taxon. Likewise summing the annual totals for all taxons of fish larvae may not yield exactly the grand total for number of fish larvae entrained.

FISH EGG AND LARVAE PROCESSING

Fish eggs and larvae were removed from samples with the aid of a dissecting binocular microscope. In late 1978 a staining technique using Lignin Pink was employed for use with some of the samples difficult to pick because of vast amounts of algae and/or detritus. This stain was used sparingly, but did expedite larval extraction. Larvae samples were first washed with tap water using a screened bucket. Dilute acid was then added and the sample remained in the acid for 45 min. The acid was then rinsed from the sample with tap water and the stain added. After at least 1 h of staining, the sample was rinsed again with tap water and examined. Development and refinement of this technique continued in 1979.

Once larvae were extracted from samples, they were measured to the nearest 0.1 mm (total length), except when samples contained more than 20 larvae of any one species, at which time lengths were determined to the nearest 0.5 mm. Number, species and length of larvae as well as number of

eggs found were entered on coding forms and later keypunched to allow for computer data processing. A computer program was developed to adjust numbers of larvae and eggs to number per 1000 m^3 of water filtered using flowmeter readings. (See METHODS - FISH LARVAE TOWS for details).

Knowledge of fish populations and spawning times in southeastern Lake Michigan, specimen comparisons with those stored in the Great Lakes Regional Fish Larvae Collection (Dorr and Jude in press) and the taxonomic works of Dorr et al. (1976), Hogue et al. (1976), Lippson and Moran (1974), Nelson and Cole (1975) and Jude et al. (1979b) were used in larval fish identifications.

Problem areas exist in some species identifications of larval fish and some identifications are still tentative. Alewife and gizzard shad could not be distinguished from one another once yolk-sac absorption had taken place. Separation of longnose and white suckers was also difficult. For a continued description of these problematic areas, see species sections in RESULTS AND DISCUSSION - FISH LARVAE AND FISH EGGS.

Quality Assurance

A quantitative evaluation of the effectiveness of our larval fish processing procedures was conducted. To ensure that larval fish samples were processed efficiently, a quality control program was initiated in 1979. A random selection of 10%, or 187 of the 1985 field and entrainment samples collected, was conducted and these samples were processed. Techniques were the same as those discussed in FISH EGG AND LARVAE PROCESSING; however, to effect consistency all reprocessed samples were handled by a single individual.

Of 101 Lake Michigan samples reprocessed, an average of 11.5% of the larvae in these samples was missed. Only two intake canal samples were reprocessed, resulting in an average of 10.7% larvae recovery. Of the 23 Pigeon Lake samples handled, an average of 7.1% of the larvae was overlooked in initial processing. A greater percentage of larvae was missed in entrainment samples: sixty-one samples were reevaluated, and an average of 14.5% of the larvae was not removed from samples during initial processing.

The degree of difficulty in picking through the sample (presence of algae, zooplankton and debris), as well as time of year and thus size of larvae, obviously influenced the percentage of larval fish recovered from samples during the second processing. Lake Michigan samples tended to be filled with small crustaceans and particles of debris. Relatively transparent larvae in these samples were usually small, which made processing difficult. In Pigeon Lake the samples were often filled with large pieces of aquatic macrophytes and, although these can hamper effective processing, vigorous washing usually dislodges larval fish. Due to species composition and warmer eutrophic environment, larvae from Pigeon Lake tended to be larger, deeper bodied, more robust and heavily pigmented, and were therefore more easily recognizable. Entrainment samples are perhaps the most difficult to process. Larval fish become damaged on the net during collection and are not easily

removed from the dark, debris-laden samples. All larvae found during reprocessing were added to the sample totals; no adjustments were made to samples not repicked in the process.

LABORATORY ANALYSIS OF JUVENILE AND ADULT FISH

Each replicate from seine, gill net and trawl catches was labeled and kept separately in plastic bags. Fish were processed fresh when time permitted, or otherwise frozen at the Campbell Plant or on board the R/V Mysis (trawl catches). For laboratory examination, fishes in each bag were thawed, separated by species, then grouped into size classes. When large numbers of a particular size class for an unusually abundant species were present, a subsample was randomly selected from the group and the remaining fish weighed (herein referred to as the mass weight) and discarded. The following data on each fish from the subsample were recorded: total length (to the nearest millimeter, caudal fin pinched), weight (to the nearest 0.1 g using a P1000 Mettler balance), sex, gonad condition, presence or absence of food in the stomach, fin clips, lamprey scars and evidence of diseases and parasites. Large fish and fish in the mass weight (over 1000 g) were weighed with a hanging scale spring balance (K023G Chatillon) to the nearest 20 g.

Gonad condition of adult fish was described according to five stages of development: 1) underdeveloped, 2) moderately developed - for female, eggs discernible, but not fully ripe, 3) ripe, 4) ripe-running - sex products exiting with application of moderate pressure, 5) spent. Other gonad conditions recorded included: 6) immature, 7) unable to ascertain sex on adult fish, 8) reabsorbed eggs - for female fish, 9) fish decomposed or mutilated so that sex was impossible to determine.

All fish were identified to species using Hubbs and Lagler (1958), Trautman (1957), Scott and Crossman (1973) and Eddy (1957) with the exception of the genus Coregonus (subgenus Leucichthys). Satisfactory keys for this subgenus do not exist because of unsettled questions on the validity of several species (Scott and Crossman 1973) and the possibility of their introgression (Wells and McLain 1973). The only adult Leucichthys that can be positively identified is the lake herring, Coregonus artedii. Other Leucichthys, adult or juvenile, were pooled as unidentified coregoninae (code XC). These were believed to be mostly bloaters, C. hoyi.

DATA PROCESSING AND CALCULATIONS

For each adult and juvenile fish examined, the following information was recorded on a 75-column coding form, one fish per line: date and time of sample collection, type of gear, day or night series, station, species code, a unique incrementing number, length, weight, sex, gonad condition and presence or absence of food in the stomach.

Data on subsampled fish were recorded on consecutive lines each having a subsampling code. Special columns were reserved for the corresponding mass weight. Computer programs searched for subsampled lots and calculated number

of fish processed, their mean weight and the total number of mass-weighed fish not examined. Mass-weighed fish were proportionally assigned to length intervals based on the number of sampled fish found in each length interval. Fish were divided visually by length into many narrow size classes when originally subsampled to minimize error associated with this reconstruction of sample length frequencies.

Fisheries data were keypunched, then read onto computer disks and tapes. For the bulk of our statistical analyses, we used the Michigan Interactive Data Analysis System (MIDAS) which was developed by the Statistical Laboratory of the University of Michigan. From our computer programs, we obtained summary statistics on seasonal gonad condition, temperature-catch relationships, catches by month, gear type, station and day and night series and length-frequency histograms. Most plots used in the report were drawn by the CALCOMP plotter at the University of Michigan Computing Center.

Gill nets were set for as close to 12 h as possible when there was available daylight or darkness. Due to unpredictable weather conditions and changing day length, however, actual time gill nets were fished varied from 6 h 30 min to 12 h 45 min; most were around 8 h duration. Gill net catches for calculating statistics were adjusted to approximate numbers caught per 12 h by assuming that catch was a linear function of time. The above assumption is not completely valid as gill net catch-per-unit-time might be expected to decrease as the net fills with fish, but increased accuracy could not justify the cost of determining a precise relationship for each species.

DEFINITION OF TERMS

Adult fish length intervals - for figures describing total lengths of adult fish, individuals were assigned to 10-mm intervals. For example, the 30-mm length interval would include fish from 25 to 34 mm.

Beach zone - refers to that area of water, usually less than 1.5 m, that is accessible to wading during seining and fish larvae sampling activities. Includes only beach stations.

Fish larvae - any larval fish less than or equal to 25.4 mm in total length.

Fry - any fish greater than 25.4 mm in total length caught in plankton nets. Fish were usually 25.5 to 100 mm.

Inshore - refers to that area of water between the shoreline and 21 m.

Larval fish length intervals - for figures describing total lengths of larval fish, a specimen was assigned to a 0.5-mm interval based on total length. For example, larvae 0.3 mm would be assigned to the interval 0.5 mm (which includes all larvae 0.1 to 0.5 mm), 5.6-mm larvae would be assigned to the interval 6 mm (which encompasses 5.6- to 6.0-mm larvae).

Nearshore - refers to that area of water less than or equal to 3 m and

includes Lake Michigan stations P, A, B, Q, R, I, J and Pigeon Lake stations V, S, X and Z.

Offshore - term for that area of water, not beach zone, 21 m deep or greater. There are no stations in this zone. Same as deepwater.

Open water - refers to that area of water, which is not beach zone and includes all stations 6 m to 21 m which were usually sampled by boat and which usually had no or very few aquatic macrophytes present. The area includes Lake Michigan stations C, D, E, F, L, N, O, W and Pigeon Lake station M.

Transition zone - area of water from 1.5 to 3 m.

Zone of influence - that area of Lake Michigan aquatic habitat actually or potentially affected by the presence of the intake and discharge structures of Units 1 and 2 and Unit 3 (future) and their associated withdrawal and discharge of cooling water.

YOY - young-of-the-year - fish in their first year of life. They become yearlings January 1.

Water temperature intervals - catch of adult fish was assigned to 2 C water temperature intervals for the purposes of establishing temperature-catch relationships. For example, the 3 C temperature interval would include fish caught between 2.0 and 3.9 C.

STATISTICS

BMD8V was used to perform the analyses of variance (Statistical Research Laboratory 1975). Attained significance values for ANOVA F-statistics were generated from TABLES, an interactive computer program for statistical probability distributions (Fox 1978). The Michigan Interactive Data Analysis System (MIDAS - Fox and Guire 1973) was used for analyses of ANOVA residuals. Residuals, defined as the difference between the cell mean and actual data value, were examined to determine how well ANOVA model assumptions were met (Draper and Smith 1966). A FORTRAN program was written to compute the LDTR (Least Detectable True Ratios).

SCUBA

An attempt via SCUBA to survey the fish populations in the intake canal was undertaken in 1979. Once each month, three divers swam from the south to the north end of the intake canal. The swim started at the north perimeter of station Z and terminated 130 m south of the screenhouse. One diver swam along the east bank and two swam down the center of the channel.

RESULTS AND DISCUSSION

STATISTICS

Introduction

One objective of this study is to see how fish populations fluctuate from year to year and to detect differences in fish abundances between the reference area and the zone of influence (area of Lake Michigan affected by the intake of cooling water and discharge of heated water). Catch-per-unit-effort (CPE) was utilized as an index of abundance, providing estimates of relative population size. Note that CPE is an index of numerical abundance and not an absolute measure of population size. Replicate samples were taken using trawls, seines and gill nets. Each sample represented one unit of effort. One unit of trawling effort was defined as a 10-min tow, one unit of gill net effort was defined as one lift of one replicate of the net adjusted to a standard 12-h fishing period and one unit of seining effort was defined as a 61-m sweep parallel to shore with the seine. There are many problems equating units of effort of one gear type to effort units of another, so abundance indices for different gear types are not directly comparable (Lawrie and Rahrer 1973). However, CPE values for different gear types may provide complementary information about a particular fish population. For example, individual fish which might avoid trawls might be captured by gill nets. Conversely, fish which are too small to be captured in gill nets are likely to be caught with seines and trawls. Assuming that biases of each gear are constant over time and sampling stations, standardized units of effort for each gear ensured that CPE was a reliable index of abundance for fish populations (Ricker 1975). Although the data were analyzed separately for each gear type for a particular species, the aggregate of the results for all gear types was reviewed for that species.

Design and Analysis Considerations

Statistical analyses were performed on catch data of the six most abundant species of fish collected during field sampling in Lake Michigan. They included: spottail shiner, alewife, rainbow smelt, yellow perch, trout-perch and unidentified coregoninae. Differences in fish abundance between the reference area and the zone of influence were examined using analysis of variance (ANOVA). These analyses will hopefully provide information to determine what impact the power plant may be having on fish populations. The experimental designs (Table 4) were analyzed as completely crossed, factorial models with YEAR, MONTH, STATION (or AREA), DEPTH (in some designs) and TIME OF DAY (for some designs) as design variables. All factors were considered fixed. The response variable was either number of fish per unit of effort or a transform thereof. We transformed raw data by taking $\log_{10}$ of the sum of CPE plus one. The addition of one ensured inclusion of zero values of CPE in the transformed data. This transformation was designed to reduce data variance so ANOVA assumptions might be more closely met.

Table 4. Experimental designs employed to analyze catch-per-unit-of-effort data for the six most abundant species caught in the vicinity of the J. H. Campbell Plant, eastern Lake Michigan, 1977 through 1979.

Design label (includes gear)	Factor	Level of factors	Species examined	Comments
Trawl I	YEAR MONTH STATION TIME OF DAY	1977-1979 June-December reference: C(6 m-south) zone of influence: L(6 m-north) day, night	Spottail shiner Alewife Rainbow smelt Yellow perch Trout-perch Unidentified coregoninae	For alewives, trout-perch, and unidentified coregoninae data for months June through November were analyzed. Yellow perch data for months July through September were analyzed. Trout-perch data are for night catches only.
Trawl II	YEAR MONTH AREA DEPTH TIME OF DAY	1978-1979 May-December reference: C(6 m-south), D(9 m-south) zone of influence: L(6 m-north), N(9 m-north) 6 m, 9 m day, night	Spottail shiner Alewife Rainbow smelt Yellow perch Trout-perch Unidentified coregoninae	For alewives, trout-perch, and unidentified coregoninae data for months June through November were analyzed, for yellow perch months July through September were analyzed. Trout-perch data are for night catches only.

Table 4 . Continued.

Design label (includes gear)	Factor	Level of factors	Species examined	Comments
Bottom gill net I	YEAR	1977-1979	Spottail shiner Alewife Yellow perch	Catch data for trout-perch and unidentified coregoninae were not analyzed because they were too few. Alewife and yellow perch data were analyzed for July to September only.
	MONTH	July, August, September, November.		
	STATION	reference: C(6 m-south) zone of influence: L(6 m-north)		
	TIME OF DAY	day, night		
Bottom gill net II	YEAR	1978-1979	Spottail shiner Alewife Yellow perch	For alewife, data from May through September were analyzed. Yellow perch data for August through September only were analyzed.
	MONTH	May-November		
	STATION	reference: C(6 m-south) zone of influence: L(6 m-north)		
	TIME OF DAY	day, night		
Surface gill net I	YEAR	1977-1979	Alewife	Only alewife data were analyzed; catches of other species were too low.
	MONTH	July, September.		
	STATION	reference: C(6 m-south) zone of influence: L(6 m-north)		
	TIME OF DAY	day, night		

Table 4. Continued.

Design label (includes gear)	Factor	Level of factors	Species examined	Comments
Surface gill net II	YEAR	1978-1979	Alewife	Only alewife data were analyzed; catches of other species were too low.
	MONTH	May-September		
	STATION	reference: C(6 m-south) zone of influence: L(6 m-north)		
	TIME OF DAY	day, night		
Seine	YEAR	1977-1979	Spottail shiner Alewife	For alewife, data for July through September only were analyzed.
	MONTH	June-November		
	STATION	reference: P (south reference) zone of influence: Q (south discharge) R (north discharge)		
	TIME OF DAY	day, night		

The factorial ANOVA designs were chosen according to species, gear type and presence of zero values in data (Table 4). The YEAR factor was examined for each gear type to see if population abundances were significantly different among the 3 yr. The MONTH factor was expected to explain a considerable amount of variation attributable to seasonal changes in fish abundance. The STATION factor was designed to test for differences between the reference station C (6 m, south) and the zone of influence station L (6 m, north) for trawl and gill net models, while for seining, this factor was designed to test for differences between beach reference station P (1 m, south) and treatment stations Q (south discharge) and R (north discharge). AREA was used in the second trawl design to examine differences between the reference area [stations C (6 m, south) and D (9 m, south)] and the zone of influence [stations C (6 m, north) and N (9 m, north)]. Depth was used in this design to compare abundances between the 6- and 9-m contours. The data for 6- and 9-m stations were analyzed only for 1978-1979 because trawl samples were not collected at station N (9 m, north) in 1977. TIME OF DAY was employed in all of the designs except for the trout-perch design and was intended to account for diel migrations into and out of the study area. TIME OF DAY was not used in trout-perch ANOVAs because only night samples were included in the designs. Day catches of trout-perch were low with many zero catches. Deletion of day samples from ANOVA improved reliability of results. A main effect or an interaction was considered significant if the attained significance (p) of its statistical test was less than 0.01 ($p < 0.01$); the main effect or interaction was considered highly significant if the attained significance (p) for its test was less than 0.001 ($p < 0.001$).

Assumptions for the ANOVA model are: 1) residuals are normally distributed, 2) variances of the population are constant for all partitions of the population and 3) observations are statistically independent. Balanced factorial ANOVA are robust to the assumptions of normality and homogenous variances. In other words, moderate departures from these assumptions do not completely invalidate results of the model. Violation of the independence assumption may have more serious consequences. Examination of frequency histograms of residuals and plots of residuals versus cell means indicate that the assumptions of normality and homogeneous variances were not seriously violated.

Given that these assumptions are met, sensitivity of the ANOVA model to detect the alternate hypothesis can be calculated. In this study, we were interested in detecting significant differences between stations (or areas). The least detectable true change (LDTC) is the minimum difference in mean abundance between stations (or areas) that can be detected by our experimental design. The formula we used for LDTC, as presented by Jude et al. (1979b), is as follows:

$$\delta = s(2/n)^{1/2}(t_{\alpha,\nu} + t_{2(1-P),\nu})$$

Where: δ = least detectable true change (LDTC)

s = within cell standard deviation of the ANOVA (i.e., the square root of the mean square error)

n = number of observations in each of the two groups being compared

α = significance level

t = Student's t-statistic

ν = degrees of freedom for the error sum of squares of the ANOVA

P = power (the probability that a true difference will be judged significant by the ANOVA test)

Results for all ANOVA models (Table 4) were computed using both raw and log-transformed data. Data for all species and gear types were initially screened by calculating mean catch (which was equal in value to mean CPE since effort for collecting any one sample was always one), its variance and percentage of zero values in the design matrix. Summary statistics for those data sets considered amenable to further statistical analyses (Table 5) showed that percentage of zero catches for these data usually exceeded 25%. Consequently, distribution of values was generally bimodal with modes at zero and near the geometric means. The transformation did, however, yield residuals which were slightly closer to meeting ANOVA assumptions than residuals from raw-data values. Unless stated otherwise, future references to abundance when discussing the ANOVA results will refer to geometric mean abundance derived from log-transformed data. Geometric means for various partitions of the data were derived by back transforming cell means from log-transformed data. For example, if $\bar{x}$ represents the mean catch for log-transformed data, then $x = 10^{\bar{x}}$ is the geometric mean catch. Use of log-transformed data can yield cell means which are not in the same ranking order as cell means from the original data. If so, the geometric means will also differ in ranking order since the exponential function is monotonic.

When using log-transformed data, the LDTC or δ is expressed as the change in the logarithm of fish numbers and not in terms of the actual numbers of fish. Back transforming yields 10^{δ}; 10^{δ} represents the ratio of the mean number of fish per unit effort plus one for reference station C (or the reference area) to that of experimental station L (or the zone of influence in the case of the second trawl design). In the transformed coordinate system (i.e., log-transformed system) changes will be detectable if $|\bar{x}_C - \bar{x}_L| > \delta$ where $\bar{x}_C$ and $\bar{x}_L$ refer to the log-transformed mean catches at stations C and L respectively. In the original coordinate system, differences are detectable whenever:

$$10^{-\delta} > \frac{x_C}{x_L} > 10^{\delta}$$

We shall refer to the quantity 10^{δ} as the least detectable true ratio (LDTR).

Results for the first ANOVA model for trawls (Table 6) showed significant differences among years 1977 through 1979 for catches of spottail shiners, yellow perch, trout-perch and unidentified coregoninae (Fig. 5). For spottail shiner and unidentified coregoninae, geometric mean abundance

Table 5. Descriptive statistics for catch-per-unit-of-effort (CPE) data used in the experimental designs for the six most abundant species caught in the vicinity of the J. H. Campbell Plant, eastern Lake Michigan for years 1977 through 1979. N is number of samples in the experimental design, $\overline{X}$ is the mean number of fish caught per one unit of effort for the data set.

	N	Maximum catch no. fish	$\overline{X}$	Standard deviation	Percentage of zero catch data
TRAWL I					
Spottail shiner	168	254	13.7	35.2	42.3
Alewife	144	4287	123.6	467.5	24.3
Rainbow smelt	168	1017	88.0	154.9	8.3
Yellow perch	72	90	6.0	13.8	45.8
Trout-perch	72	63	16.1	17.0	6.9
Unidentified coregoninae	144	395	20.8	56.9	36.8
TRAWL II					
Spottail shiner	256	438	17.4	49.7	36.3
Alewife	192	4287	171.2	524.4	31.8
Rainbow smelt	256	1994	117.8	223.9	7.8
Yellow perch	96	90	5.0	12.3	50.0
Trout-perch	112	119	18.9	20.7	5.4
Unidentified coregoninae	192	503	33.8	68.8	19.8
BOTTOM GILL NET I					
Spottail shiner	96	160	13.6	29.7	43.8
Alewife	72	195	16.7	38.7	23.6
Yellow perch	72	25	5.4	6.0	27.8
BOTTOM GILL NET II					
Spottail shiner	112	160	19.9	35.2	40.2
Alewife	80	185	15.4	33.8	16.3
Yellow perch	32	25	6.7	6.4	18.8
SURFACE GILL NET I					
Alewife	48	213	31.1	43.3	25.0
SURFACE GILL NET II					
Alewife	80	213	24.7	39.4	36.3
SEINE					
Spottail shiner	216	1678	69.6	214.1	28.2
Alewife	108	6174	332.9	897.8	16.7

Table 6. Summary of ANOVA results for spottail shiners, alewives, rainbow smelt, yellow perch, trout-perch and unidentified coregoninae caught in trawls at stations C (6 m, south) and L (6 m, north) near the J. H. Campbell Plant, eastern Lake Michigan, 1977 through 1979. * denotes a significant main effect or interaction ($0.001 < p \leq 0.01$); ** denotes a highly significant main effect or interaction ($p \leq 0.001$). See Table 4 for design descriptions.

Source of Variation	SPOTTAIL SHINER (1977-1979, 7 mo) F-Stat.	SPOTTAIL SHINER Signif.	ALEWIFE (1977-1979, 6 mo) F-Stat.	ALEWIFE Signif.	RAINBOW SMELT (1977-1979, 7 mo) F-Stat.	RAINBOW SMELT Signif.	YELLOW PERCH (1977-1979, 3 mo) F-Stat.	YELLOW PERCH Signif.	TROUT-PERCH (1977-1979, 6 mo) F-Stat.	TROUT-PERCH Signif.	UNIDENTIFIED COREGONINAE (1977-1979, 6 mo) F-Stat.	UNIDENTIFIED COREGONINAE Signif.
Main Effects												
Year (Y)	13.2654	<0.0001**	2.7419	0.0712	1.1910	0.3090	19.6490	<0.0001**	11.7620	0.0001**	72.6843	<0.0001**
Month (M)	56.2789	<0.0001**	52.3055	<0.0001**	59.6676	<0.0001**	26.9810	<0.0001**	50.1932	<0.0001**	28.7151	<0.0001**
Station (S)	21.9836	<0.0001**	0.3117	0.5784	19.4671	<0.0001**	15.3940	0.0004**	6.3137	0.0166	1.7549	0.1895
Time (T)	681.4351	<0.0001**	24.0487	<0.0001**	84.6576	<0.0001**	0.2293	0.6350			56.6064	<0.0001**
Interactions												
YxM	21.4389	<0.0001**	14.1462	<0.0001**	35.3795	<0.0001**	51.4226	<0.0001**	13.0273	<0.0001**	16.1082	<0.0001**
YxS	4.5162	0.0137	0.8476	0.4327	1.7620	0.1780	9.1986	0.0006**	10.5249	0.0003**	5.1878	0.0079*
MxS	1.2872	0.2720	1.5816	0.1762	1.6672	0.1392	7.8179	0.0015*	0.6119	0.6913	2.7057	0.0269
YxT	23.8103	<0.0001**	5.6072	0.0055*	4.8479	0.0102	10.8268	0.0002**			5.9248	0.0041*
MxT	30.4468	<0.0001**	2.5344	0.0360	12.2889	<0.0001**	1.6725	0.2020			3.2952	0.0098*
SxT	5.0861	0.0267	0.0000	0.9964	9.5045	0.0028*	0.3399	0.5635			2.1491	0.1470
YxMxS	3.0860	0.0012*	1.7666	0.0825	2.1269	0.0233	12.1130	<0.0001**	2.3917	0.0271	4.2697	0.0001**
YxMxT	13.0525	<0.0001**	4.7354	<0.0001**	4.3413	<0.0001**	4.3726	0.0055*			2.1711	0.0293
YxSxT	0.9401	0.3947	4.7417	0.0116	1.4010	0.2520	2.4804	0.0979			2.5173	0.0878
MxSxT	1.8412	0.1008	2.6162	0.0313	2.5214	0.0271	8.8011	0.0008**			2.6495	0.0296
YxMxSxT	2.3439	0.0120	2.1836	0.0284	1.9621	0.0381	5.2433	0.0020*			1.8719	0.0634
Mean Square Error	0.0373		0.1858		0.0766		0.0382		0.0362		0.0968	

increased each year from 1977 through 1979. Yellow perch catch peaked in 1978, and 1979 levels fell below 1977 catch values. Trout-perch catch also peaked in 1978, but 1979 levels remained above 1977 catch values.

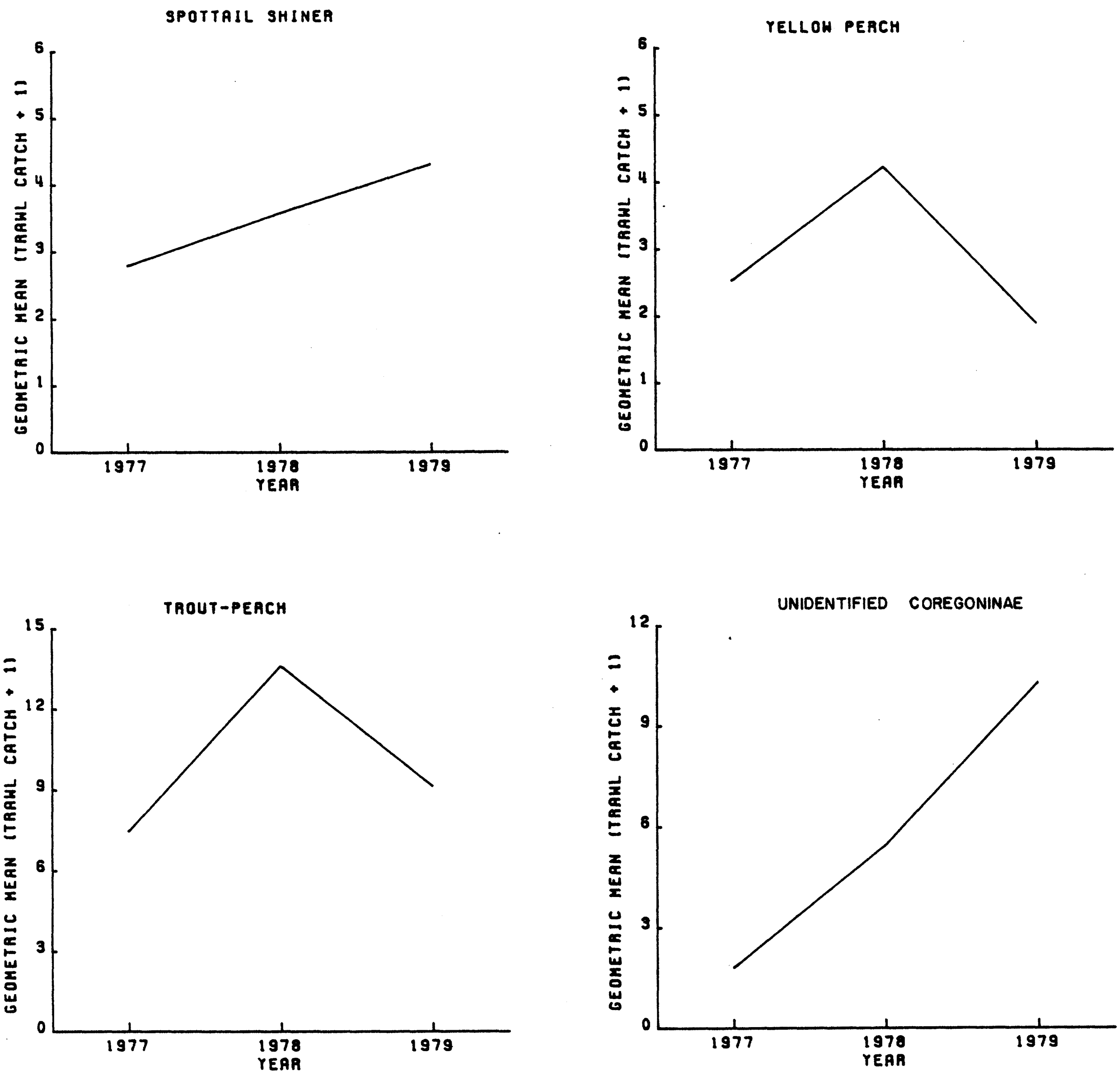


Fig. 5 . Geometric mean number plus one of spottail shiners, yellow perch, trout-perch and unidentified coregoninae caught in trawls at stations C (6 m, south) and L (6 m, north) near the J.H. Campbell Plant, eastern Lake Michigan, 1977 through 1979. Graphs show the YEAR effect.

MONTH effects and YEAR x MONTH interactions were significant for all species. Peaks in geometric mean abundance shifted from month to month over the years. Station effects were significant for spottail shiner, rainbow smelt and yellow perch; geometric mean abundance at station L (6 m, north) was significantly greater than that for reference station C (6 m, south) for these species. YEAR x STATION interactions were significant for yellow perch, trout-perch and unidentified coregoninae, indicating that patterns of abundance at the two stations differed among years (Fig. 6). Geometric mean abundance was significantly higher at night than at day for all species except yellow perch (TIME OF DAY was not a factor in trout-perch ANOVAs). Numerous significant YEAR x TIME OF DAY and MONTH x TIME OF DAY interactions indicated that diel patterns of trawl catch varied seasonally or among years for all species.

The second trawl design (Table 4) included the factors YEAR (1978 and 1979), MONTH, AREA [reference stations C and D (6 and 9 m, south, respectively) and zone of influence stations L and N (6 and 9 m, north, respectively)], DEPTH and TIME OF DAY. Geometric mean abundance was significantly higher in 1979 than 1978 for spottail shiners and unidentified coregoninae and significantly lower in 1979 than 1978 for yellow perch, all patterns similar to those exhibited for the first trawl design (Fig. 5). MONTH effects and YEAR x MONTH interactions were highly significant for all species, indicating seasonal variation in abundance and changing patterns of seasonal abundance between years. Geometric mean abundance was significantly higher at stations L and N (in the zone of influence) than at the reference area (stations C and D) for spottail shiner, rainbow smelt, yellow perch and unidentified coregoninae. However, all species exhibited significant YEAR x AREA (Fig. 7) or MONTH x AREA (Fig. 8) interactions, indicating that patterns of abundance at the two areas varied by month or by year. DEPTH was a significant main effect for yellow perch and unidentified coregoninae with more yellow perch caught at 6-m stations and more unidentified coregoninae caught at 9-m stations. Geometric mean abundance was significantly higher in night trawls than day trawls for all species except yellow perch (day catches of trout-perch were excluded from ANOVA). DEPTH and TIME OF DAY also entered into several significant two-way and three-way interactions (Table 7), indicating complex patterns of depth and diel distribution for all species.

Results of the first design for bottom gill net ANOVAs (Table 4) showed that mean abundance among years was significantly different for spottail shiner and yellow perch. The YEAR main effect was very close to significance for alewife (Table 8). Spottail shiner and yellow perch also displayed significant MONTH effects. YEAR x MONTH interactions were highly significant for all three species, indicating seasonal abundance varied over the years. STATION effects were not significant for the three species, but STATION was involved in several first-order interactions (Fig. 9). YEAR x STATION interactions were significant for alewife and yellow perch. For alewife, abundance at reference station C (6 m) increased yearly while levels at station L (6 m, north) were relatively constant. In contrast, yellow perch abundance declined yearly at station C, but increased each year at station L. The MONTH x STATION interaction was significant for yellow perch; abundance peaked in August at station L, but increased through September at reference

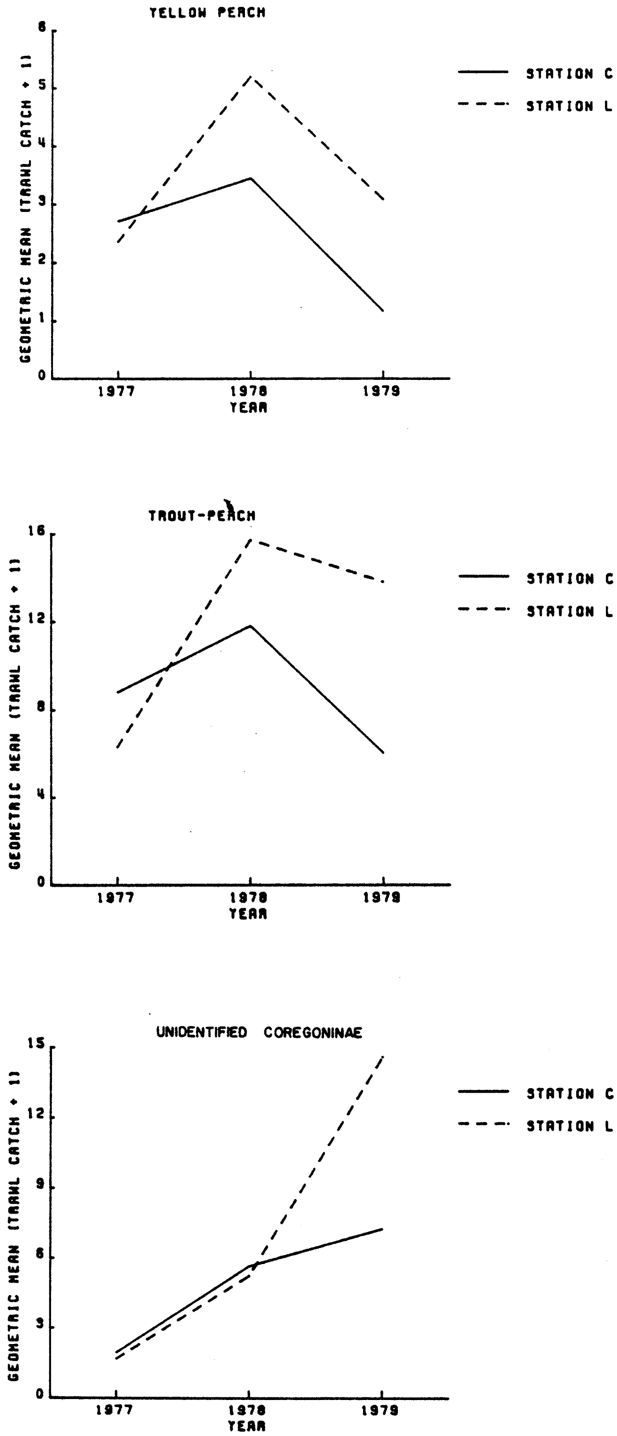


Fig. 6. Geometric mean number plus one of yellow perch, trout-perch and unidentified coregoninae caught in trawls at stations C (6 m, south) and L (6 m, north) near the J.H. Campbell Plant, eastern Lake Michigan, 1977 through 1979. Graphs show YEAR X STATION interaction.

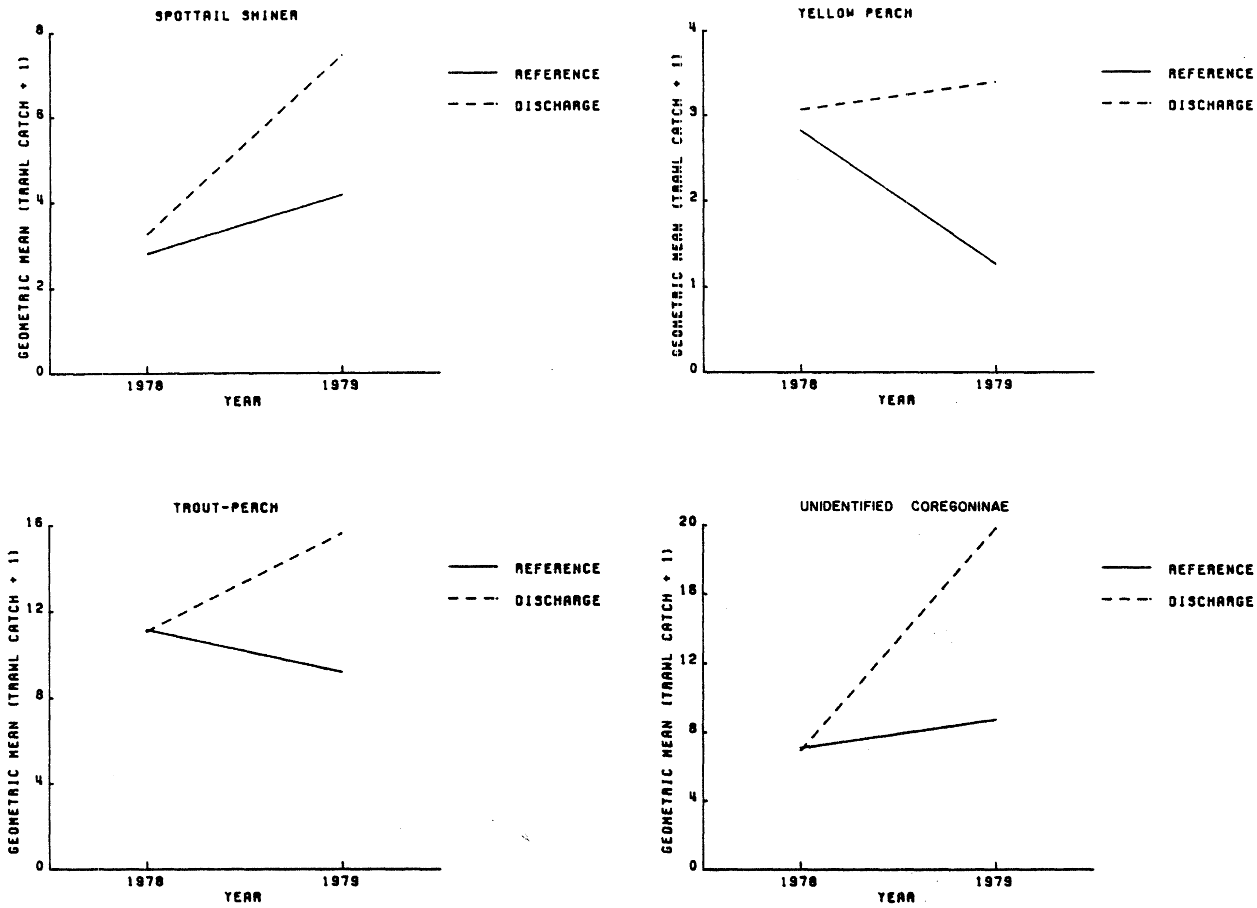


Fig. 7. Geometric mean number plus one of spottail shiners, yellow perch, trout-perch and unidentified coregoninae caught in trawls at stations C (6 m, south), D (9 m, south), L (6 m, north) and N (9 m, north) near the J. H. Campbell Plant, eastern Lake Michigan, 1978 and 1979. Graphs show YEAR X AREA interaction.

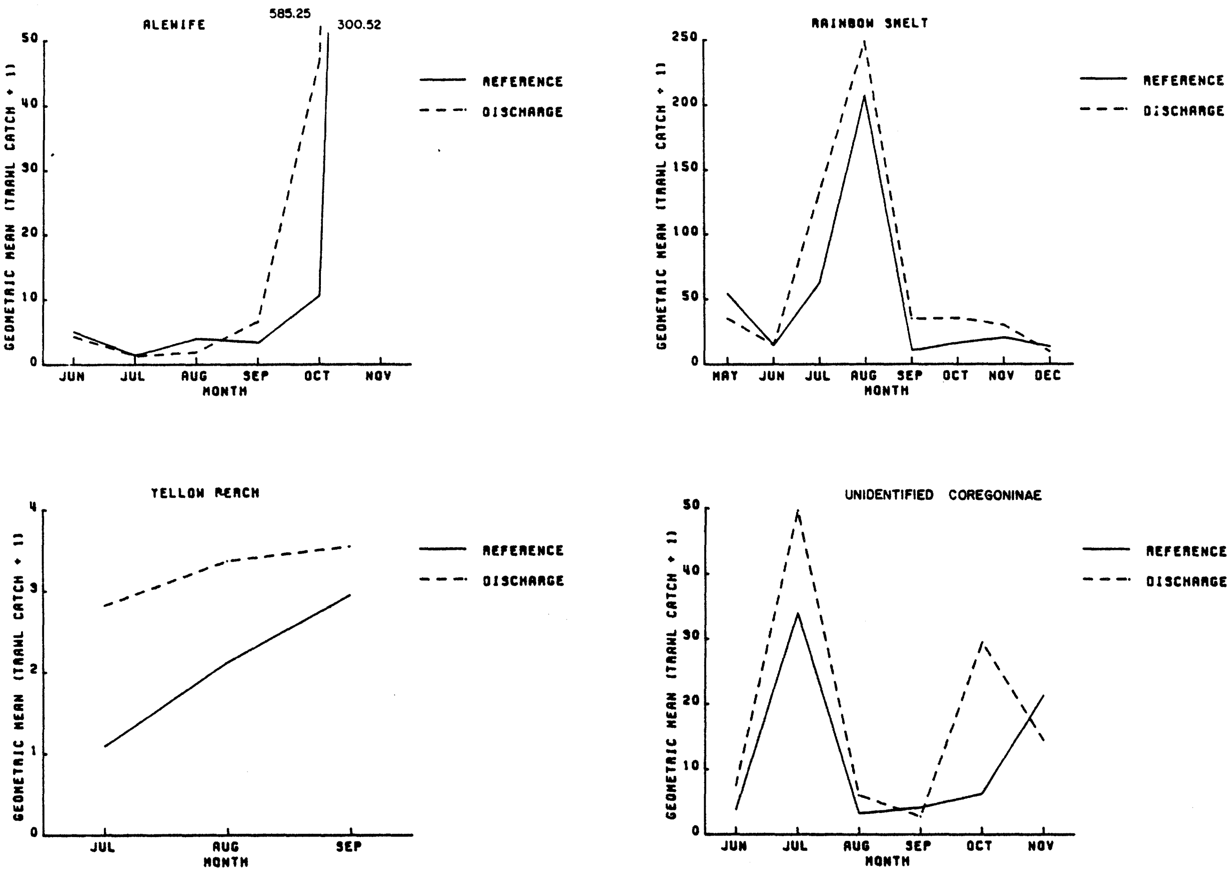


Fig. 8. Geometric mean number plus one of alewives, rainbow smelt, yellow perch and unidentified coregoninae caught in trawls at stations C (6 m, south), D (9 m, south), L (6 m, north) and N (9 m, north) near the J. H. Campbell Plant, eastern Lake Michigan, 1978 and 1979. Graphs show MONTH X AREA interaction. Only months in which sufficient numbers of each species were caught are shown.

Table 7. Summary of ANOVA results for spottail shiners, rainbow smelt, yellow perch, trout-perch and unidentified coregoninae caught in trawls at stations C (6 m, south), D (9 m, south), L (6 m, north) and N (9 m, north) near the J. H. Campell Plant, eastern Lake Michigan, 1978 and 1979. * denotes a significant main effect or interaction ($0.001 < p \leq 0.01$); ** denotes a highly significant main effect or interaction ($p \leq 0.001$). See Table 4 for design descriptions.

Source of Variation	SPOTTAIL SHINER (1978-1979, 8 mo) F-Stat.	Signif.	ALEWIFE (1978-1979, 6 mo) F-Stat.	Signif.	RAINBOW SMELT (1978-1979, 8 mo) F-Stat.	Signif.	YELLOW PERCH (1978-1979, 3 mo) F-Stat.	Signif.	TROUT-PERCH (1978-1979, 7 mo) F-Stat.	Signif.	UNIDENTIFIED COREGONINAE (1978-1979, 6 mo) F-Stat.	Signif.
Main Effects												
Year (Y)	69.3707	<0.0001**	3.8550	0.0525	1.3677	0.2444	15.5435	0.0003**	0.5697	0.4536	26.0240	<0.0001**
Month (M)	31.4077	<0.0001**	165.1706	<0.0001**	54.5471	<0.0001**	17.0742	<0.0001**	47.7969	<0.0001**	40.5018	<0.0001**
Area (A)	24.8594	<0.0001**	5.5436	0.0206	10.3346	0.0017*	37.1309	<0.0001**	7.0271	0.0104	10.4006	0.0017*
Depth (D)	0.4790	0.4901	0.0213	0.8842	4.4977	0.0359	9.2372	0.0038*	1.3777	0.2455	16.1579	0.0001**
Time (T)	592.8513	<0.0001**	25.8824	<0.0001**	16.3231	0.0001**	0.0211	0.8852			103.5212	<0.0001**
Interactions												
YxM	20.7127	<0.0001**	8.6108	<0.0001**	42.3880	<0.0001**	114.5816	<0.0001**	11.4291	<0.0001**	14.5218	<0.0001**
YxA	8.8091	0.0036*	1.1139	0.2939	2.7904	0.0973	26.2784	<0.0001**	7.3336	0.0090*	11.5805	0.0010**
MxA	1.6539	0.1262	6.0443	0.0001**	4.3461	0.0002**	6.5243	0.0031*	1.4376	0.2168	6.0175	0.0001**
YxD	16.0571	0.0001**	1.7734	0.1861	2.0750	0.1522	27.4754	<0.0001**	12.1721	0.0010**	0.0025	0.9599
MxD	3.7594	0.0010**	2.7843	0.0216	3.1061	0.0046*	13.1376	<0.0001**	1.5247	0.1870	3.8022	0.0035*
AxD	1.7607	0.1869	0.2837	0.5955	7.2283	0.0081*	3.3472	0.0735	4.5981	0.0364	0.4870	0.4869
YxT	15.8044	0.0001**	12.6051	0.0006**	9.9774	0.0020*	18.9615	0.0001**			0.1305	0.7187
MxT	27.1133	<0.0001**	5.1546	0.0003**	21.3686	<0.0001**	0.8887	0.4179			2.1099	0.0707
AxT	2.9396	0.0889	0.9879	0.3228	2.3576	0.1271	2.3499	0.1319			3.5463	0.0627
DxT	23.4833	<0.0001**	11.6661	0.0009**	38.3737	<0.0001**	0.4010	0.5296			0.8299	0.3646
YxMxA	1.4001	0.2108	1.0526	0.3916	6.7439	<0.0001**	8.8444	0.0005**	3.0126	0.0127	3.8459	0.0032*
YxMxD	6.7846	<0.0001**	1.6076	0.1654	4.8468	0.0001**	9.6857	0.0003**	4.9428	0.0004**	2.8539	0.0191
YxAxD	0.0000	0.9984	0.2809	0.5974	3.1267	0.0794	3.6292	0.0628	0.8370	0.3642	0.0661	0.7977
MxAxD	1.5407	0.1593	1.7129	0.1389	1.9899	0.0613	8.1273	0.0009**	2.5785	0.0282	1.4541	0.2121
YxMxT	8.0216	<0.0001**	12.0267	<0.0001**	9.5778	<0.0001**	2.3046	0.1107			3.2344	0.0096*
YxAxT	0.3540	0.5529	11.5630	0.0010**	3.4865	0.0642	0.0412	0.8400			0.6396	0.4258
MxAxT	4.0652	0.0005**	3.5558	0.0054*	2.3265	0.0288	11.5930	0.0001**			3.9527	0.0027*
YxDxT	3.7327	0.0556	0.1049	0.7468	4.6055	0.0338	6.4621	0.0143			3.3225	0.0714
MxDxT	5.2952	<0.0001**	2.3496	0.0466	1.0917	0.3724	0.2060	0.8145			2.9759	0.0153
AxDxT	0.2898	0.5913	1.9676	0.1639	4.2134	0.0421	0.8827	0.3522			0.0121	0.9126
YxMxAxD	3.0244	0.0056*	6.3861	<0.0001**	1.9534	0.0664	31.8622	<0.0001**	0.7265	0.6301	1.3551	0.2481
YxMxAxT	2.8207	0.0091*	4.3078	0.0014*	2.8644	0.0082*	0.5336	0.5899			2.7478	0.0230
YxMxDxT	1.4983	0.1735	0.6342	0.6741	0.6412	0.7211	3.3021	0.0453			1.0154	0.4130
YxAxDxT	0.2490	0.6186	1.6826	0.1977	0.6711	0.4142	9.5867	0.0033*			3.1879	0.0773
MxAxDxT	2.5696	0.0164	2.3215	0.0489	0.9956	0.4375	1.7515	0.1844			0.7850	0.5630
YxMxAxDxT	0.8942	0.5132	1.4843	0.2021	0.4703	0.8546	12.2739	0.0001**			1.3980	0.2319
Mean Square Error	0.0642		0.1563		0.1115		0.0347		0.0520		0.1380	

Table 8. Summary of ANOVA results for spottail shiners, alewives and yellow perch caught in bottom gill nets at stations C (6 m, south) and L (6 m, north) near the J. H. Campbell Plant, eastern Lake Michigan, 1977 through 1979 and 1978 through 1979. * denotes a significant main effect or interaction ($0.001 < p \leq 0.01$); ** denotes a highly significant main effect or interaction ($p \leq 0.001$). See Table 4 for design descriptions.

Source of Variation	SPOTTAIL SHINER (1977-1979, 4 mo) F-Stat.	Signif.	ALEWIFE (1977-1979, 3 mo) F-Stat.	Signif.	YELLOW PERCH (1977-1979, 3 mo) F-Stat.	Signif.	SPOTTAIL SHINER (1978-1979, 7 mo) F-Stat.	Signif.	ALEWIFE (1978-1979, 5 mo) F-Stat.	Signif.	YELLOW PERCH (1978-1979, 2 mo) F-Stat.	Signif.
Main Effects												
Year (Y)	39.4886	<0.0001**	5.1671	0.0106	7.2815	0.0022*	5.3090	0.0249	1.1556	0.2888	12.8219	0.0025*
Month (M)	23.2467	<0.0001**	3.3372	0.0468	11.4411	0.0001**	4.6452	0.0007**	2.2408	0.0817	1.9679	0.1798
Station (S)	0.3167	0.5762	1.8191	0.1858	4.5848	0.0391	66.1647	<0.0001**	31.2214	<0.0001**	0.0014	0.9707
Time (T)	86.9993	<0.0001**	0.4496	0.5068	0.2905	0.5932	41.2774	<0.0001**	6.6624	0.0136	0.1798	0.6772
Interactions												
YxM	11.9598	<0.0001**	8.4094	0.0001**	13.7153	<0.0001**	2.1220	0.0649	3.0302	0.0284	1.0997	0.3099
YxS	1.6792	0.1973	7.9418	0.0014*	41.4985	<0.0001**	2.4580	0.1226	0.3016	0.5859	8.8419	0.0090*
MxS	0.8134	0.4928	2.5124	0.0952	5.8947	0.0061*	2.8179	0.0182	5.3685	0.0015*	0.0020	0.9651
YxT	21.7743	<0.0001**	13.7005	<0.0001**	0.1544	0.8575	0.2697	0.6056	0.9160	0.3443	0.4216	0.5254
MxT	7.3183	0.0004**	8.7144	0.0008**	6.0242	0.0055*	4.0687	0.0019*	2.3275	0.0727	0.0127	0.9116
SxT	0.0815	0.7766	0.0633	0.8028	0.6366	0.4302	37.1763	<0.0001**	7.1073	0.0110	0.0658	0.8008
YxMxS	9.6913	<0.0001**	1.4497	0.2378	4.4599	0.0050*	2.8541	0.0170	3.7796	0.0106	1.2084	0.2879
YxMxT	38.9249	<0.0001**	16.2246	<0.0001**	7.8063	0.0001**	10.5542	<0.0001**	4.1571	0.0066*	0.1155	0.7384
YxSxT	2.7177	0.0762	3.2213	0.0516	0.8966	0.4169	7.5390	0.0081*	0.2154	0.6450	0.6737	0.4238
MxSxT	8.7358	0.0001**	1.9812	0.1527	2.2537	0.1196	5.1950	0.0003**	2.8931	0.0341	0.0871	0.7717
YxMxSxT	4.8321	0.0006**	6.0116	0.0008**	5.5986	0.0013*	6.8873	<0.0001**	9.2846	<0.0001**	0.1671	0.6881
Mean Square Error	0.0538		0.1070		0.0469		0.0920		0.0885		0.1349	

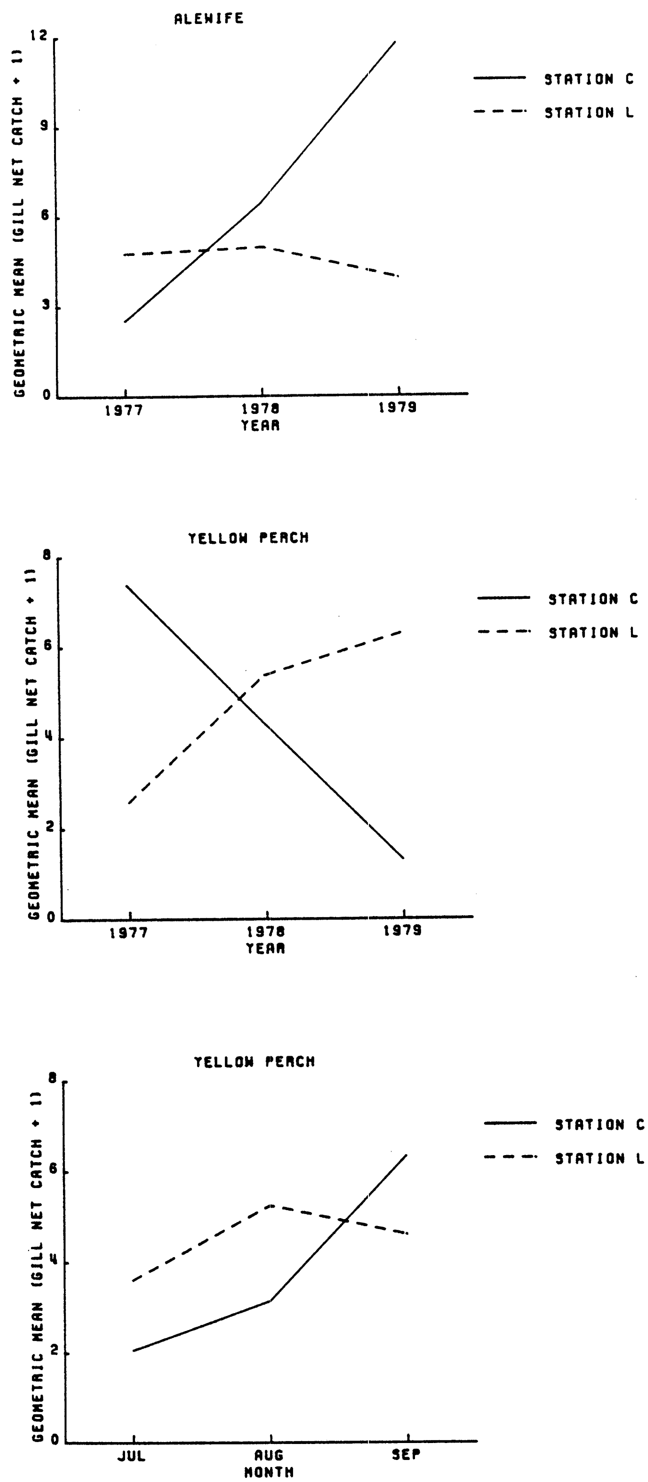


Fig. 9. Geometric mean number plus one of alewives and yellow perch caught in bottom gill nets at stations C (6 m, south) and L (6 m, north) near the J.H. Campbell Plant, eastern Lake Michigan, 1977 through 1979. Graphs show YEAR X STATION interaction for alewives and yellow perch, and MONTH X STATION interaction for yellow perch.

station C (Fig. 9). STATION was also involved in several higher order interactions. TIME was a significant main effect only for spottail shiner, with night abundance greater than day abundance. TIME OF DAY was a factor in several significant interactions for all three species.

A second design for bottom gill nets incorporated different levels of MONTHs and dropped 1977 from the YEAR factor (Table 4). Results were similar to the first bottom gill net design (Table 8) with some interesting differences. The YEAR effect was not significant for spottail shiner, and YEAR x MONTH interactions were not significant for all three species, indicating that seasonal abundance patterns did not differ between 1978 and 1979. STATION was a significant main effect for spottail shiner and alewife, with geometric mean abundance higher at station C (6 m, south) than station L (6 m, north). STATION also entered into significant two-way interactions for each species (Fig. 10). Yellow perch exhibited a significant YEAR x STATION effect similar to that appearing in the first bottom gill net design (Fig. 9). The MONTH x STATION interaction was significant for alewife; abundance peaked in July at station C, but remained at lower levels across all months at station L (Fig. 10). Geometric mean abundance for spottail shiner showed a greater increase from day to night samples at station C than at station L, producing a highly significant STATION x TIME interaction.

Only alewives were caught in sufficient numbers in surface gill nets to permit analysis of variance. The only significant effect in the first ANOVA design was TIME OF DAY when a higher abundance of alewives was observed at night than during the day; no significant interactions appeared (Table 9). The second surface gill net design incorporated more months, but deleted 1977 from the YEAR factor. TIME OF DAY and MONTH were the only significant main effects (Table 9). Monthly geometric mean abundance of alewives rose from 5.15 in June to a peak of 16.32 in August, then declined to 4.59 in October. Almost all three-way and four-way interactions were significant, indicating that MONTH and TIME OF DAY effects varied by year and by station.

Sharply reduced catches of yellow perch and rainbow smelt in seines in 1979 allowed only spottail shiner and alewife data to be analyzed using ANOVA (Table 4). Results of ANOVA revealed significant YEAR and MONTH main effects and YEAR x MONTH interactions for both spottail shiner and alewife (Table 10). MONTH x STATION interactions were also significant for both species, revealing considerable variation in seasonal abundance. Geometric mean abundance declined each year (1977 through 1979) for both species (Fig. 11). STATION was a highly significant main effect for spottail shiner (Fig. 11) with highest geometric mean abundance at beach station R (north discharge) and lowest abundance at beach station P (south reference). TIME was a significant main effect for alewife, with day abundance exceeding night abundance. Significant MONTH x TIME interactions for both species indicated that diel patterns of abundance differed from month to month. All ANOVA factors were involved in three-way or four-way interactions for both species, indicating that observed patterns of fish abundance were dependent on all levels of the ANOVA design.

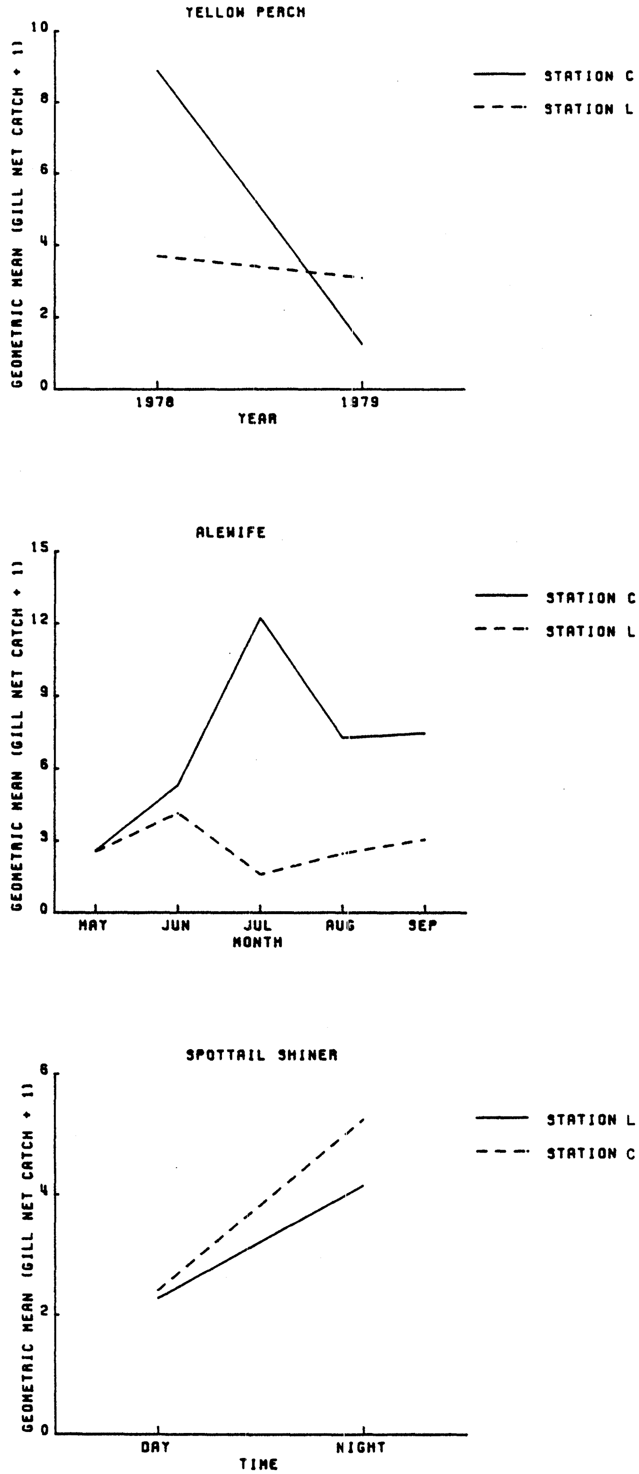


Fig. 10. Geometric mean number plus one for yellow perch, alewives and spottail shiners caught in bottom gill nets at stations C (6 m, south) and L (6 m, north) near the J.H. Campbell Plant, eastern Lake Michigan, 1978 and 1979. Graphs show the YEAR X STATION interaction for alewives and the STATION X TIME interaction for spottail shiners.

Table 9. Summary of ANOVA results for alewives caught in surface gill nets at stations C (6 m, south) and L (6 m, north) near the J. H. Campbell Plant, eastern Lake Michigan for 1977 through 1979 and 1978 through 1979. * denotes a significant main effect or interaction ($0.001 < p \leq 0.01$); ** denotes a highly significant main effect or interaction ($p \leq 0.001$). See Table 4 for design descriptions.

Source of Variation	ALEWIFE (1977-1979, 2 mo) F-Stat.	ALEWIFE (1977-1979, 2 mo) Signif.	ALEWIFE (1978-1979, 5 mo) F-Stat.	ALEWIFE (1978-1979, 5 mo) Signif.
Main Effects				
Year (Y)	0.9554	0.3988	1.1720	0.2855
Month (M)	7.7790	0.0102	5.4822	0.0013*
Station (S)	0.5591	0.4619	4.1710	0.0478
Time (T)	40.6459	<0.0001**	149.0199	<0.0001**
Interactions				
YxM	1.6010	0.2225	1.7269	0.1631
YxS	1.2211	0.3126	0.5413	0.4662
MxS	0.9574	0.3376	1.7846	0.1510
YxT	1.8410	0.1804	1.8268	0.1841
MxT	2.3247	0.1404	1.7778	0.1523
SxT	2.2602	0.1458	0.5159	0.4768
YxMxS	2.4164	0.1106	4.6876	0.0034*
YxMxT	0.9748	0.3917	1.6756	0.1746
YxSxT	3.7970	0.0369	10.5336	0.0024*
MxSxT	2.4482	0.1308	6.4168	0.0004**
YxMxSxT	5.0991	0.0143	4.4716	0.0044*
Mean Square Error	0.2407		0.1466	

Table 10. Summary of ANOVA results for spottail shiners and alewives caught in seines at stations P (south reference), Q (south discharge) and R (north discharge) near the J. H. Campbell Plant, eastern Lake Michigan for years 1977 through 1979. * denotes a significant main effect or interaction (0.001 < p ≤ 0.01); ** denotes a highly significant main effect or interaction (p ≤ 0.001). See Table 4 for design descriptions.

Source of Variation	SPOTTAIL SHINER (1977-1979, 6 mo)		ALEWIFE (1977-1979, 3 mo)	
	F-stat.	Signif.	F-stat.	Signif.
Main Effects				
Year (Y)	37.5206	<0.0001**	78.3682	<0.0001**
Month (M)	62.8519	<0.0001**	26.1684	<0.0001**
Station (S)	10.1430	0.0001**	1.4624	0.2407
Time (T)	0.5333	0.4668	9.4029	0.0034*
Interactions				
YxM	8.5655	<0.0001**	5.2778	0.0012*
YxS	0.5947	0.6672	0.8473	0.5015
MxS	4.6623	<0.0001**	4.0650	0.0059*
YxT	0.2469	0.7817	1.9198	0.1565
MxT	8.2157	<0.0001**	20.4180	<0.0001**
SxT	3.1413	0.0472	1.1604	0.3210
YxMxS	3.3714	<0.0001**	2.6447	0.0160
YxMxT	10.6366	<0.0001**	2.1860	0.0828
YxSxT	0.6589	0.6219	4.6470	0.0027*
MxSxT	2.0444	0.0355	2.4268	0.0589
YxMxSxT	2.8572	0.0003**	5.6022	<0.0001**
Mean Square Error	0.1733		0.2582	

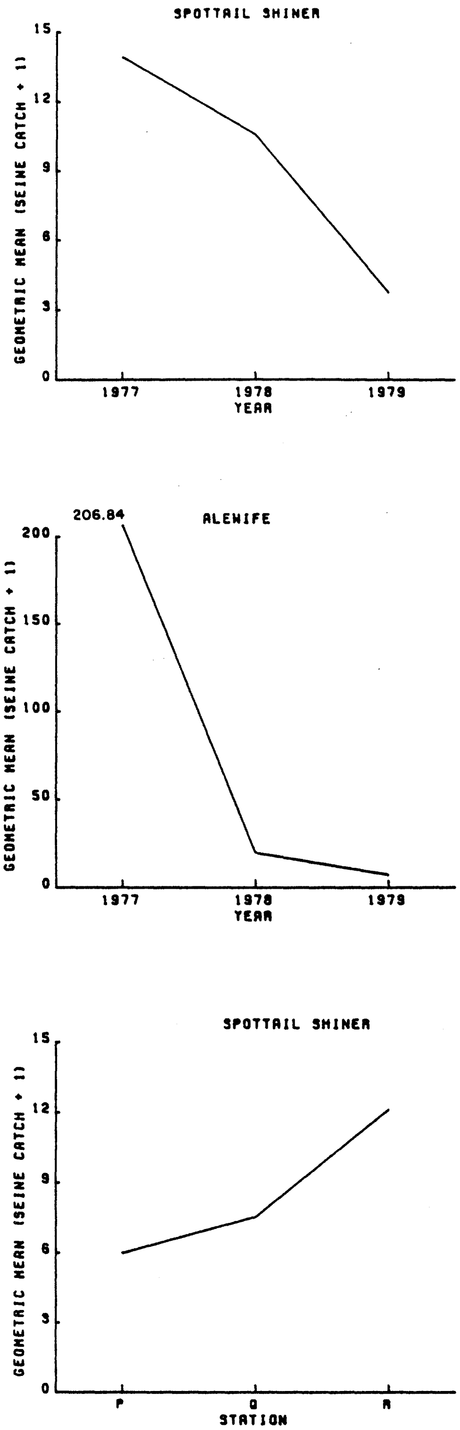


Fig. 11. Geometric mean number plus one for spottail shiners and alewives caught in seines at beach stations P (south reference), Q (south discharge) and R (north discharge) near the J.H. Campbell Plant, eastern Lake Michigan, 1977 through 1979. Graphs show the YEAR effect for spottail shiners and alewives and the STATION effect for spottail shiners.

The LDTRs (Least Detectable True Ratios) calculated are ratios involving geometric mean number of fish. Power analyses involving least detectable true ratios showed that most sampling designs employed could probably detect increases in mean abundance from one station (or area) to another in the range of 15% to 50% and decreases from 13% to 33% (for α = 0.01 and Power = 0.95) (Table 11). Overall, power of ANOVAs including 1977 through 1979 data was slightly lower than power of ANOVAs including just 1977 and 1978 data (Jude et al. 1979a). This is due mostly to increased variance caused by differences in catch distribution between 1979 and previous years. LDTRs were highest for surface gill nets. Among species, power to detect significant changes was lowest for alewife irrespective of gear used, which may be related to alewife migration and highly variable recruitment of their young. The trawl was probably the best gear for assessing impacts of plant operation. LDTRs for spottail shiner, rainbow smelt, yellow perch and trout-perch were very similar. Given that assumptions of the power analysis have been met, changes in trawl catch exceeding 39% and -28% should be detectable for these species. For unidentified coregoninae the LDTR is quite high with changes not being detected unless outside the 45% and -31% range. Changes in mean alewife catch of less than 66% and greater than -40% could not be detected by the given experimental design. This effect is not a reflection of the adequacy of the experimental design, but rather an indication of the naturally high variations in abundance of alewives within the inshore zone.

Lake Michigan is subject to biological, chemical and physical processes which may bring about changes in fish populations. This makes assessing potential plant impact very difficult. Further compounding of this difficulty occurred as dredging began in 1978 and continued through 1979 in the discharge area as part of construction of an offshore intake and discharge system for Unit 3 of the Campbell Plant. The effects of this dredging on fish populations in the zone of influence area are unknown. Unusually high YOY trawl catches were taken in 1978 from experimental station L (6 m, north) for spottail shiner (September, night) and alewife (October, night); yellow perch were concentrated in July 1978 seines and July through September trawl and gill net catches near dredging operations.

Despite these complications, some general patterns emerged from the analyses. Month effects were significant for almost all ANOVA designs. These effects were related to spawning activity, inshore migration (perhaps for feeding) and recruitment of YOY fish. YOY fish made up almost the entire catch for the large catch peaks observed during August through October, and for alewife in November. Only rainbow smelt failed to reveal significant differences among years. Both spottail shiner and unidentified coregoninae exhibited highly significant YEAR main effects in trawl ANOVAs. Both species increased in abundance each year from 1977 through 1979. Spottail shiners revealed a similar pattern in gill net catches, although the second gill net design showed that the change in abundance from 1978 to 1979 was not significant. Spottail shiner abundance in seine catches was also significantly different among years, but in this case abundance declined each year from 1977 through 1979. Alewives also declined in abundance each year in seine catches, producing a highly significant YEAR main effect. Alewives showed no significant differences among years in trawl or gill net ANOVAs.

Table 11. Least detectable true ratio (LDTR) for each experimental design employed for spottail shiners, alewives, rainbow smelt, yellow perch, trout-perch and unidentified coregoninae caught in the vicinity of the J.H. Campbell Plant, eastern Lake Michigan, 1977 through 1979. Alpha (α) is the size of the type I error; it is the probability of rejecting the null hypothesis given that it is true; power is the probability of rejecting the null hypothesis given it is false. See Table 4 for design descriptions.

DESIGN	α	SPOTTAIL SHINER Power		ALEWIFE Power		RAINBOW SMELT Power		YELLOW PERCH Power		TROUT-PERCH Power		UNIDENTIFIED COREGONINAE Power	
		.90	.95	.90	.95	.90	.95	.90	.95	.90	.95	.90	.95
TRAWL I	.01	1.21	1.23	1.59	1.66	1.31	1.35	1.35	1.39	1.34	1.38	1.39	1.44
	.02	1.19	1.22	1.54	1.61	1.29	1.32	1.32	1.36	1.31	1.35	1.36	1.41
	.05	1.17	1.19	1.47	1.53	1.26	1.29	1.28	1.32	1.28	1.31	1.32	1.36
	.10	1.15	1.18	1.41	1.48	1.23	1.26	1.25	1.29	1.24	1.28	1.28	1.32
TRAWL II	.01	1.22	1.25	1.44	1.49	1.30	1.34	1.28	1.31	1.32	1.36	1.41	1.45
	.02	1.21	1.23	1.40	1.45	1.28	1.31	1.26	1.29	1.30	1.33	1.38	1.42
	.05	1.18	1.21	1.36	1.40	1.25	1.28	1.23	1.26	1.26	1.29	1.33	1.37
	.10	1.16	1.19	1.32	1.36	1.22	1.25	1.20	1.23	1.23	1.26	1.29	1.34
BOTTOM GILL NET I	.01	1.36	1.40	1.66	1.74			1.40	1.44				
	.02	1.33	1.37	1.60	1.68			1.36	1.41				
	.05	1.29	1.33	1.52	1.59			1.32	1.36				
	.10	1.26	1.30	1.46	1.53			1.28	1.32				
BOTTOM GILL NET II	.01	1.45	1.50	1.54	1.61			2.46	2.68				
	.02	1.41	1.46	1.50	1.56			2.29	2.50				
	.05	1.36	1.41	1.43	1.49			2.08	2.26				
	.10	1.32	1.37	1.38	1.44			1.92	2.09				
SURFACE GILL NET I	.01			2.58	2.83								
	.02			2.41	2.64								
	.05			2.18	2.39								
	.10			2.01	2.20								
SURFACE GILL NET II	.01			1.75	1.84								
	.02			1.68	1.77								
	.05			1.59	1.68								
	.10			1.52	1.60								
SEINE	.01	1.56	1.62	2.17	2.33								
	.02	1.51	1.58	2.06	2.21								
	.05	1.45	1.51	1.90	2.05								
	.10	1.40	1.45	1.79	1.92								

Yellow perch abundance was not significantly different from 1977 to 1978 (Jude et al. 1979a), but gill net and trawl ANOVAs revealed 1979 abundance to be significantly lower than yellow perch abundance in 1978. Trout-perch abundance in trawl samples declined in 1979 from peak abundance in 1978, which was significantly higher than 1977 levels.

While analysis of variance of 1977-1978 trawl and gill net data revealed only one significant difference between STATIONs or AREAs (rainbow smelt were more abundant in station L trawl samples than in reference station C samples), inclusion of 1979 data produced many more significant results for STATION and AREA factors. For the second trawl ANOVA design, including 1978 and 1979 data, abundances at the zone of influence (stations L and N, 6 m and 9 m north, respectively) were significantly greater than abundances at south reference stations (C, 6 m and D, 9 m) for spottail shiner, rainbow smelt, yellow perch and unidentified coregoninae. Abundance at station L was significantly greater than abundance at reference station C for spottail shiner, rainbow smelt and yellow perch in the first trawl design, which included 1977 data. However, the pattern reversed for spottail shiner and alewife in the second bottom gill net design; abundance at 6-m reference station C was significantly greater than at station L. Changing patterns of abundance between the two areas or stations from one year to the next may reflect natural changes in population location as fish move about in inshore areas of Lake Michigan, or may be a result of increased construction activity in the vicinity of stations L and N which affected fish distribution. Such changes in preoperational years will make it more difficult to identify plant effects in operational years of Unit 3, although it will be possible to determine if changes in operational years exceed the magnitude of changes in preoperational years. Careful examination of YEAR x STATION or YEAR x AREA interactions will be required if changes in distribution continue in operational years.

Significant TIME OF DAY differences noted in ANOVA results may be due to 1) horizontal movements within or out of the sampling area, 2) vertical movements within the water column or 3) avoidance of fishing gear during daylight. Depth may be a significant factor for yellow perch (caught mainly at 6 m) and unidentified coregoninae (caught mainly at 9 m).

Interactions were difficult to analyze for ANOVA data, especially third-order interactions. The strongest interactions were, generally, YEAR x MONTH and MONTH x TIME. The significant YEAR x MONTH interaction reflected different spawning and resultant YOY recruitment peaks between years. In the case of gill nets, interactions reflected movement inshore or offshore possibly for spawning, but also for feeding. The MONTH x TIME interactions may be attributed to 1) relatively low day catch throughout the year, but widely varying night catch (e.g., for spottail shiner and trout-perch), 2) a few (or just one) unusually high day or night catches during 1 mo (e.g., for rainbow smelt), 3) an upwelling drastically decreasing or increasing the abundance of fish and 4) abundance of a certain age-group at a particular depth contour dependent upon time of day; e.g., catches in seines for alewife

and spottail shiner. Adults and yearlings present in spring and early summer in the beach zone were caught mostly at night, while YOY in late summer and fall were caught mostly during the day.

In summary, ANOVA provided some insight into the biology of the species studied despite the many complications in studying inshore fish populations of Lake Michigan. STATION (or AREA) differences may provide some information on plant impact, although changes in the pattern of STATION (or AREA) differences among preoperational years will require careful examination of YEAR x STATION or YEAR x AREA interactions. The ANOVA is limited by three assumptions, a crucial one being the independence of observations which is probably violated for data from these fish populations. Time series analysis is recommended when sufficient data become available to make such an analysis worthwhile. Time series analysis takes advantage of non-independence of observation and has been shown to be a helpful tool in environmental monitoring (Box and Tiao 1975). Unfortunately, this technique requires several years of data.

ADULT AND JUVENILE FISH

This section contains adult and juvenile fish data from collections made during 1979 in the vicinity of the J.H. Campbell Plant. During 1979, 56 species of fish were collected in the study area, representing 18 families. During both 1977 and 1978, 64 species from 21 families were caught. Differences in number of species caught during 1979 and 1977-1978 in general were caused by the occasional capture of incidental species in the area. A systematic list of all species collected during this study in 1979 (Table 12) contains common and scientific names and is arranged alphabetically by family. Limnological and weather data recorded during sampling periods are shown by gear type in Appendixes 1, 2 and 3.

For purposes of our analysis, a species was designated major if it represented more than 0.5% of the total catch for Lake Michigan and 1.0% of the total catch for Pigeon Lake. Lake Michigan major species included: rainbow smelt, alewife, spottail shiner, unidentified coregoninae, trout-perch, yellow perch, white sucker and johnny darter. Major species in Pigeon Lake included: yellow perch, alewife, spottail shiner, bluegill, johnny darter and bluntnose minnow. All other species were designated minor species.

Species were treated differently, depending on abundance in our samples. Discussions of major species included seasonal, spatial and diel distributions of various size and age-groups. We attempted to explain the results of the study on the basis of biological and physical considerations and compared the findings to those available in the literature. Gonad data were used to identify spawning periods and explain distribution and were only presented for major and some minor species. Numbers of fish examined for gonad condition that are presented in each gonad table reflected the number of fish actually processed. Due to our subsampling procedures (see METHODS - LABORATORY ANALYSIS OF JUVENILE AND ADULT FISH), gonad data could be biased since the most numerous size intervals of fish were underrepresented. Data from some major species are presented concerning water temperatures where a particular size fish was most often caught. Using length-frequency histograms, we were

Table 12. Scientific name, common name and abbreviations for all species of fish captured from J. H. Campbell Plant study areas January through December 1979. An X denotes presence in Lake Michigan, Pigeon Lake and/or impingement samples. Names assigned according to Bailey et al. 1970.

Scientific and Common Name	Abbreviation	Pigeon Lake	Lake Michigan	Impingement
Acipenseridae				
Acipenser fulvescens Rafinesque Lake sturgeon	LG		X	
Amiidae				
Amia calva Linnaeus Bowfin	BF	X		X
Atherinidae				
Labidesthes sicculus (Cope) Brook silverside	SV	X		
Catostomidae				
Carpiodes cyprinus (Lesueur) Quillback	QL			X
Catostomus catostomus (Forster) Longnose sucker	LS	X	X	X
Catostomus commersoni (Lacépède) White sucker	WS	X	X	X
Moxostoma anisurum (Rafinesque) Silver redhorse	MA		X	
Moxostoma macrolepidotum (Lesueur) Shorthead redhorse	SR		X	X
Moxostoma erythrurum (Rafinesque) Golden redhorse	GR		X	
Centrarchidae				
Ambloplites rupestris (Rafinesque) Rock bass	RB	X		X
Lepomis cyanellus Rafinesque Green sunfish	GN		X	
Lepomis gibbosus (Linnaeus) Pumpkinseed	PS	X		X
Lepomis macrochirus Rafinesque Bluegill	BG	X		X
Micropterus dolomieui Lacépède Smallmouth bass	SB	X		X
Micropterus salmoides (Lacépède) Largemouth bass	LB	X		X
Pomoxis nigromaculatus (Lesueur) Black crappie	BC	X		X

Table 12. Continued.

Scientific and Common Name	Abbreviation	Pigeon Lake	Lake Michigan	Impingement
Clupeidae				
Alosa pseudoharengus (Wilson) Alewife	AL	X	X	X
Dorosoma cepedianum (Lesueur) Gizzard shad	GS	X	X	X
Cottidae				
Cottus bairdi Girard Mottled sculpin	MS	X	X	X
Cottus cognatus Richardson Slimy sculpin	SS		X	X
Cyprinidae				
Carassius auratus (Linnaeus) Goldfish	GF	X		X
Cyprinus carpio Linnaeus Carp	CP		X	X
Notemigonus crysoleucas (Mitchill) Golden shiner	GL	X		X
Notropis atherinoides Rafinesque Emerald shiner	ES	X	X	X
Notropis cornutus (Mitchill) Common shiner	CS	X		X
Notropis hudsonius (Clinton) Spottail shiner	SP	X	X	X
Notropis stramineus (Cope) Sand shiner	SH	X		
Pimephales notatus (Rafinesque) Bluntnose minnow	BM	X	X	
Pimephales promelas Rafinesque Fathead minnow	PP	X		X
Cyprinodontidae				
Fundulus diaphanus (Lesueur) Banded killifish	BK	X		
Esocidae				
Esox americanus vermiculatus Lesueur Grass pickerel	GP	X		
Esox lucius Linnaeus Northern pike	NP	X		X

Table 12. Continued.

Scientific and Common Name	Abbreviation	Pigeon Lake	Lake Michigan	Impingement
Gadidae				
Lota lota (Linnaeus) Burbot	BR			X
Gasterosteidae				
Pungitius pungitius (Linnaeus) Ninespine stickleback	NS	X	X	X
Ictaluridae				
Ictalurus melas (Rafinesque) Black bullhead	BB	X		X
Ictalurus natalis (Lesueur) Yellow bullhead	YB	X		X
Ictalurus nebulosus (Lesueur) Brown bullhead	BN	X		X
Ictalurus punctatus (Rafinesque) Channel catfish	CC		X	X
Noturus gyrinus (Mitchill) Tadpole madtom	MT	X		X
Pylodictis olivaris (Rafinesque) Flathead catfish	FC			X
Osmeridae				
Osmerus mordax (Mitchill) Rainbow smelt	SM	X	X	X
Percidae				
Stizostedion vitreum vitreum (Mitchill) Walleye	WL			X
Etheostoma nigrum Rafinesque Johnny darter	JD	X	X	
Perca flavescens (Mitchill) Yellow perch	YP	X	X	X
Percina caprodes (Rafinesque) Logperch	LP	X		X
Percina maculata (Girard) Blackside darter	BD	X		
Percopsidae				
Percopsis omiscomaycus (Walbaum) Trout-perch	TP	X	X	X

Table 12. Continued.

Scientific and Common Name	Abbreviation	Pigeon Lake	Lake Michigan	Impingement
Petromyzontidae				
Petromyzon marinus Linnaeus Sea lamprey	SL			X
Salmonidae				
Coregonus clupeaformis (Mitchill) Lake whitefish	LW		X	
Coregonus spp. Unidentified coregoninae	XC	X	X	X
Oncorhynchus kisutch (Walbaum) Coho salmon	CM	X	X	X
Oncorhynchus tshawytscha (Walbaum) Chinook salmon	CH	X	X	X
Prosopium cylindraceum (Pallas) Round whitefish	RW		X	
Salmo gairdneri Richardson Rainbow trout	RT		X	X
Salmo trutta Linnaeus Brown trout	BT	X	X	X
Salvelinus namaycush (Walbaum) Lake trout	LT		X	X

able to separate YOY from adults and compare each group's distribution and behavior. Biological aspects related to temperature preference, predation and feeding habits were discussed when pertinent. Statistical analyses were done on catches of major species in Lake Michigan to determine differences between months, stations C (6 m, south) and L (6 m, north) and time of day (see RESULTS AND DISCUSSION - STATISTICS). When enough data were available, size range, spatial and diel behavior patterns, spawning times and catch temperatures were discussed for minor species.

Monthly catch results for each gear type by lake for all species (Tables 13-18) showed that in Lake Michigan trawls collected the most fish (64,286) followed numerically by seines (6291 fish), bottom gill nets (5816 fish) and finally surface gill nets (1804 fish collected). Combining data from all gear types showed rainbow smelt and alewives were predominant in Lake Michigan catches, accounting for 38.4% and 36.4% of the total catch, respectively. In 1977 and 1978, alewives were much more prominent in samples collected. Alewives comprised 68% and 49% of the total Lake Michigan catch during 1977 and 1978 respectively. In Pigeon Lake only seines were used for sampling during 1979. Yellow perch dominated the catch, comprising 43.7% of the total. Fewer perch were caught in the previous 2 yr of sampling. Alewives and spottail shiners comprised a substantial part of the Pigeon Lake catch during all 3 yr. In 1979 alewives represented 27.6% and spottail shiners comprised 17.0% of the catch. Species numbers by size interval were compiled for each month by lake for all sampling gear combined (Appendix 6). For major species in Lake Michigan and Pigeon Lake, monthly length-frequency distributions were compiled for each gear type (Appendix 7).

Impingement samples at the Campbell Plant in 1979 were comprised mostly of alewives (54.4% of total) and gizzard shad (33.3% of total) (Table 19). As in 1978, all other impinged species individually made up less than 5.0% of the total catch.

Table 13. Summary of all fish species caught by all gear types in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan, April-December 1979.

	MONTHS										
SPECIES	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	% OF TOTAL
RAINBOW SMELT	305	3367	211	2108	17306	4275	599	1037	820	30028	38.400
ALEWIFE	0	449	1199	677	2703	1193	4259	17846	164	28490	36.434
SPOTTAIL SHINER	31	1313	3442	1748	1315	417	783	219	206	9474	12.116
UNIDENTIFIED COREGONINAE	0	8	309	2730	405	429	392	1431	9	5713	7.306
TROUT-PERCH	4	440	137	514	274	171	136	72	7	1755	2.244
YELLOW PERCH	12	13	36	103	103	87	11	40	200	605	0.774
WHITE SUCKER	0	47	42	113	42	158	7	4	0	413	0.528
JOHNNY DARTER	7	99	78	37	33	68	50	17	16	405	0.518
NINESPINE STICKLEBACK	2	55	143	167	1	0	1	3	1	373	0.477
LAKE TROUT	9	13	13	22	13	27	87	37	1	222	0.284
LONGNOSE SUCKER	0	48	14	97	4	30	12	[illegible]	0	208	0.266
SLIMY SCULPIN	61	65	2	1	1	0	1	1	24	156	0.199
BROWN TROUT	27	16	13	9	4	12	5	2	0	88	0.113
CHINOOK SALMON	4	21	16	11	2	10	1	2	0	67	0.086
ROUND WHITEFISH	2	4	4	0	2	6	19	6	1	44	0.056
GIZZARD SHAD	3	1	1	1	2	2	21	2	2	35	0.045
RAINBOW TROUT	17	1	0	0	0	0	5	6	0	29	0.037
LAKE WHITEFISH	0	0	9	12	1	5	0	0	0	27	0.035
COHO SALMON	4	4	0	0	3	4	3	0	0	18	0.023
CARP	2	0	1	0	2	1	2	2	0	10	0.013
GOLDEN REDHORSE	0	0	2	7	0	0	1	0	0	10	0.013
EMERALD SHINER	3	2	0	0	2	0	0	0	0	7	0.009
CHANNEL CATFISH	0	0	0	0	1	3	2	0	1	7	0.009
SHORTHEAD REDHORSE	0	0	2	0	0	1	1	0	0	4	0.005
BLUNTNOSE MINNOW	0	0	0	0	0	0	3	0	0	3	0.004
SILVER REDHORSE	0	0	0	0	0	1	2	0	0	3	0.004
MOTTLED SCULPIN	0	0	0	0	0	0	0	0	1	1	0.001
GREEN SUNFISH	0	0	0	0	0	0	0	1	0	1	0.001
LAKE STURGEON	0	1	0	0	0	0	0	0	0	1	0.001
TOTALS	493	5967	5674	8357	22219	6900	6403	20731	1453	78197	

Table 14. Summary of all fish species caught by bottom gill nets in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan, April-November 1979.

	MONTHS									
SPECIES	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	SUM	% OF TOTAL
SPOTTAIL SHINER	17	397	679	664	401	217	220	75	2670	45.908
ALEWIFE	0	87	510	132	248	242	2	0	1221	20.994
RAINBOW SMELT	8	36	5	0	91	276	4	0	420	7.221
WHITE SUCKER	0	47	42	110	40	156	7	4	406	6.981
UNIDENTIFIED COREGONINAE	0	0	28	183	2	13	0	1	227	3.903
YELLOW PERCH	5	5	17	32	39	78	6	36	218	3.748
LONGNOSE SUCKER	0	47	12	93	3	29	11	3	198	3.404
LAKE TROUT	9	11	6	15	13	22	73	27	176	3.026
TROUT-PERCH	1	10	11	7	0	11	10	39	89	1.530
BROWN TROUT	26	8	8	5	2	7	4	0	60	1.032
ROUND WHITEFISH	2	3	4	0	0	6	17	5	37	0.636
LAKE WHITEFISH	0	0	9	8	0	3	0	0	20	0.344
CHINOOK SALMON	2	1	1	2	1	6	1	1	15	0.258
GIZZARD SHAD	2	1	0	0	2	0	9	1	15	0.258
GOLDEN REDHORSE	0	0	2	7	0	0	1	0	10	0.172
CARP	2	0	1	0	0	1	2	1	7	0.120
RAINBOW TROUT	7	0	0	0	0	0	0	0	7	0.120
CHANNEL CATFISH	0	0	0	0	1	3	2	0	6	0.103
COHO SALMON	2	0	0	0	0	3	0	0	5	0.086
SHORTHEAD REDHORSE	0	0	2	0	0	1	1	0	4	0.069
SILVER REDHORSE	0	0	0	0	0	1	2	0	3	0.052
SLIMY SCULPIN	1	0	0	0	0	0	0	0	1	0.017
LAKE STURGEON	0	1	0	0	0	0	0	0	1	0.017
TOTALS	84	654	1337	1258	843	1075	372	193	5816	

Table 15. Summary of all fish species caught by surface gill nets in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan, April-November 1979.

SPECIES	MONTHS APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	SUM	%OF TOTAL
ALEWIFE	0	339	363	493	170	190	0	0	1555	86.197
RAINBOW SMELT	0	9	2	39	30	54	1	0	135	7.483
LAKE TROUT	0	1	2	2	0	2	14	6	27	1.497
BROWN TROUT	0	8	1	3	1	5	0	1	19	1.053
SPOTTAIL SHINER	0	1	3	0	2	12	0	0	18	0.998
RAINBOW TROUT	8	1	0	0	0	0	1	5	15	0.831
CHINOOK SALMON	0	2	0	3	1	4	0	1	11	0.610
UNIDENTIFIED COREGONINAE	0	0	0	7	0	0	0	0	7	0.388
TROUT-PERCH	0	0	0	0	0	5	0	0	5	0.277
COHO SALMON	2	0	0	0	0	1	2	0	5	0.277
YELLOW PERCH	0	0	0	0	0	5	0	0	5	0.277
WHITE SUCKER	0	0	0	2	0	0	0	0	2	0.111
TOTALS	10	361	371	549	204	278	18	13	1804	

Table 16. Summary of all fish species caught by seines in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan, April-November 1979.

SPECIES	MONTHS APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	SUM	%OF TOTAL
ALEWIFE	0	0	1	46	2155	160	220	5	2587	41.122
SPOTTAIL SHINER	13	171	364	1017	209	111	6	4	1895	30.122
RAINBOW SMELT	4	1321	0	178	66	82	6	1	1658	26.355
TROUT-PERCH	3	44	0	0	0	1	1	0	49	0.779
CHINOOK SALMON	2	16	14	6	0	0	0	0	38	0.604
UNIDENTIFIED COREGONINAE	0	0	4	0	0	6	0	0	10	0.159
GIZZARD SHAD	1	0	1	1	0	2	4	0	9	0.143
BROWN TROUT	1	0	3	1	1	0	1	0	7	0.111
EMERALD SHINER	3	2	0	0	2	0	0	0	7	0.111
NINESPINE STICKLEBACK	2	3	0	1	0	0	0	0	6	0.095
RAINBOW TROUT	1	0	0	0	0	0	4	1	6	0.095
COHO SALMON	0	4	0	0	0	0	1	0	5	0.079
LONGNOSE SUCKER	0	0	1	4	0	0	0	0	5	0.079
YELLOW PERCH	1	0	1	0	0	0	2	0	4	0.064
BLUNTNOSE MINNOW	0	0	0	0	0	0	3	0	3	0.048
SLIMY SCULPIN	1	0	0	0	0	0	0	0	1	0.016
WHITE SUCKER	0	0	0	1	0	0	0	0	1	0.016
TOTALS	32	1561	389	1255	2433	362	248	11	6291	

Table 17. Summary of all fish species caught by trawls in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan, April-December 1979.

	MONTHS										
SPECIES	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	SUM	%OF TOTAL
RAINBOW SMELT	293	2001	204	1891	17119	3863	598	1036	820	27815	43.268
ALEWIFE	0	23	325	6	130	601	4037	17841	164	23127	35.975
UNIDENTIFIED COREGONINAE	0	8	277	2540	403	410	392	1430	9	5469	8.507
SPOTTAIL SHINER	1	744	2396	67	703	77	557	140	206	4891	7.608
TROUT-PERCH	0	386	126	507	274	154	125	33	7	1612	2.508
JOHNNY DARTER	7	99	78	37	33	68	50	17	16	405	0.630
YELLOW PERCH	6	8	18	71	64	4	3	4	200	378	0.588
NINESPINE STICKLEBACK	0	52	143	166	1	0	1	3	1	367	0.571
SLIMY SCULPIN	59	65	2	1	1	0	1	1	24	154	0.240
LAKE TROUT	0	1	5	5	0	3	0	4	1	19	0.030
GIZZARD SHAD	0	0	0	0	0	0	8	1	2	11	0.017
ROUND WHITEFISH	0	1	0	0	2	0	2	1	1	7	0.011
LAKE WHITEFISH	0	0	0	4	1	2	0	0	0	7	0.011
LONGNOSE SUCKER	0	1	1	0	1	1	1	0	0	5	0.008
WHITE SUCKER	0	0	0	0	2	2	0	0	0	4	0.006
CARP	0	0	0	0	2	0	0	1	0	3	0.005
CHINOOK SALMON	0	2	1	0	0	0	0	0	0	3	0.005
COHO SALMON	0	0	0	0	3	0	0	0	0	3	0.005
BROWN TROUT	0	0	1	0	0	0	0	1	0	2	0.003
RAINBOW TROUT	1	0	0	0	0	0	0	0	0	1	0.002
GREEN SUNFISH	0	0	0	0	0	0	0	1	0	1	0.002
MOTTLED SCULPIN	0	0	0	0	0	0	0	0	1	1	0.002
CHANNEL CATFISH	0	0	0	0	0	0	0	0	1	1	0.002
TOTALS	367	3391	3577	5295	18739	5185	5765	20514	1453	64286	

Table 18. Summary of all fish species caught by seines in Pigeon Lake near the J. H. Campbell Plant, eastern Lake Michigan, April-November 1979.

	MONTHS									
SPECIES	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	SUM	%OF TOTAL
YELLOW PERCH	1	85	5433	1561	516	526	59	14	8195	43.707
ALEWIFE	0	0	1	1	4828	344	4	0	5178	27.616
SPOTTAIL SHINER	20	358	97	82	236	2297	30	74	3194	17.035
BLUEGILL	0	0	0	0	19	467	97	8	591	3.152
JOHNNY DARTER	11	36	77	88	51	137	60	23	483	2.576
BLUNTNOSE MINNOW	4	53	6	20	215	100	6	19	423	2.256
EMERALD SHINER	21	105	0	1	1	0	0	0	128	0.683
BROOK SILVERSIDE	0	0	2	0	4	38	20	23	87	0.464
MOTTLED SCULPIN	0	0	0	3	1	25	36	7	72	0.384
LARGEMOUTH BASS	0	0	5	4	9	37	4	1	60	0.320
BLACK CRAPPIE	0	0	1	1	1	45	0	1	49	0.261
ROCK BASS	0	0	0	7	8	13	9	0	37	0.197
TROUT-PERCH	0	0	0	1	0	7	22	0	30	0.160
PUMPKINSEED	0	0	4	6	3	10	0	0	23	0.123
WHITE SUCKER	0	1	2	17	0	2	0	0	22	0.117
GOLDEN SHINER	0	16	0	2	2	0	0	0	20	0.107
SAND SHINER	3	5	9	0	0	0	0	0	17	0.091
TADPOLE MADTOM	0	0	1	0	4	10	2	0	17	0.091
RAINBOW SMELT	0	4	0	0	5	0	6	0	15	0.080
FATHEAD MINNOW	0	6	2	5	0	1	0	1	15	0.080
LONGNOSE SUCKER	0	0	0	13	0	0	0	0	13	0.069
CHINOOK SALMON	0	2	3	6	0	0	1	0	12	0.064
BANDED KILLIFISH	0	0	3	0	2	2	2	0	9	0.048
NINESPINE STICKLEBACK	4	3	2	0	0	0	0	0	9	0.048
BROWN BULLHEAD	0	0	1	1	5	1	1	0	9	0.048
NORTHERN PIKE	0	1	3	0	0	3	1	0	8	0.043
SMALLMOUTH BASS	0	0	2	1	1	2	0	0	6	0.032
UNIDENTIFIED COREGONINAE	0	0	4	0	0	0	1	0	5	0.027
COMMON SHINER	1	1	0	0	1	0	0	1	4	0.021
COHO SALMON	0	3	0	0	0	0	0	0	3	0.016
LOGPERCH	0	0	0	3	0	0	0	0	3	0.016
BOWFIN	0	2	0	1	0	0	0	0	3	0.016
BLACKSIDE DARTER	0	0	0	1	0	1	0	0	2	0.011
GOLDFISH	0	0	0	0	0	1	1	0	2	0.011
GIZZARD SHAD	0	0	0	0	0	0	1	1	2	0.011
BROWN TROUT	0	1	0	0	0	0	0	0	1	0.005
YELLOW BULLHEAD	0	0	0	0	1	0	0	0	1	0.005
GRASS PICKEREL	0	0	0	0	0	1	0	0	1	0.005
BLACK BULLHEAD	0	1	0	0	0	0	0	0	1	0.005
TOTALS	65	683	5658	1825	5913	4070	363	173	18750	

Table 19. Summary of all fish species observed in 24-h impingement samples at the J. H. Campbell Plant, eastern Lake Michigan, January-December 1979. Numbers are not expanded.

SPECIES	MONTHS												SUM	%OF TOTAL
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC		
ALEWIFE	314	64	1	0	77	1181	1193	438	1225	1830	3343	254	9920	54.350
GIZZARD SHAD	3367	1056	520	68	1	0	1	52	24	145	542	296	6072	33.268
SPOTTAIL SHINER	53	38	203	93	36	38	190	38	9	19	80	27	824	4.515
RAINBOW SMELT	1	0	0	3	3	2	3	148	41	81	78	17	377	2.066
TROUT-PERCH	48	53	44	11	2	0	1	0	5	20	71	35	290	1.589
YELLOW PERCH	46	14	44	34	11	5	4	5	0	2	18	18	201	1.101
LARGEMOUTH BASS	36	3	3	5	0	0	0	6	0	116	13	8	190	1.041
BLACK CRAPPIE	16	4	3	18	2	1	4	2	0	3	2	8	63	0.345
NORTHERN PIKE	1	0	12	6	0	1	4	0	0	0	0	14	38	0.208
WHITE SUCKER	0	2	15	10	1	0	0	0	0	0	0	1	29	0.159
GOLDEN SHINER	4	0	7	16	0	0	0	0	0	0	0	1	28	0.153
BLUEGILL	2	0	0	1	0	0	0	0	0	12	6	2	23	0.126
CHINOOK SALMON	0	0	3	8	2	0	2	1	0	1	3	1	21	0.115
BURBOT	7	6	2	3	1	0	0	0	0	1	0	0	20	0.110
SLIMY SCULPIN	2	1	1	10	0	0	0	0	0	0	1	0	15	0.082
NINESPINE STICKLEBACK	0	0	2	1	4	2	2	0	0	1	0	1	13	0.071
WALLEYE	3	2	2	0	0	0	0	0	0	0	0	4	11	0.060
BLACK BULLHEAD	1	0	0	4	0	2	1	0	0	0	1	2	11	0.060
EMERALD SHINER	0	1	6	1	1	0	0	0	1	0	0	0	10	0.055
UNIDENTIFIED COREGONINAE	0	0	0	0	0	0	0	0	2	1	7	0	10	0.055
CHANNEL CATFISH	4	0	1	2	0	0	0	0	1	0	0	1	9	0.049
TADPOLE MADTOM	0	0	0	0	0	1	1	3	1	0	1	1	8	0.044
PUMPKINSEED	1	0	0	5	0	0	0	0	0	1	1	0	8	0.044
MOTTLED SCULPIN	0	1	1	3	0	0	0	0	0	0	1	0	6	0.033
COHO SALMON	1	0	0	1	1	0	0	1	0	2	0	0	6	0.033
LAKE TROUT	0	0	0	0	1	0	0	0	1	1	1	1	5	0.027
FATHEAD MINNOW	1	0	1	3	0	0	0	0	0	0	0	0	5	0.027
QUILLBACK	0	0	0	0	0	0	0	0	0	0	0	5	5	0.027
BROWN BULLHEAD	0	0	1	0	0	0	0	0	0	2	1	1	5	0.027
BROWN TROUT	0	2	0	2	0	0	0	1	0	0	0	0	5	0.027
ROCK BASS	0	1	0	0	0	1	0	1	0	0	2	0	5	0.027
GOLDFISH	1	0	1	1	1	0	0	0	0	0	0	0	4	0.022
BOWFIN	0	0	1	1	0	0	0	1	0	0	0	0	3	0.016
SEA LAMPREY	0	0	1	0	0	0	0	0	0	0	1	0	2	0.011
SMALLMOUTH BASS	0	0	0	0	0	1	0	0	0	1	0	0	2	0.011
FLATHEAD CATFISH	0	0	0	1	0	0	0	0	0	0	0	0	1	0.005
SHORTHEAD REDHORSE	1	0	0	0	0	0	0	0	0	0	0	0	1	0.005
RAINBOW TROUT	0	0	0	0	0	0	0	0	0	0	0	0	1	0.005
LOGPERCH	0	0	0	0	0	0	0	0	0	0	0	1	1	0.005
LONGNOSE SUCKER	0	0	0	0	0	0	0	0	0	1	0	0	1	0.005
COMMON SHINER	0	0	0	0	0	0	0	1	0	0	0	0	1	0.005
CARP	0	0	0	0	0	1	0	0	0	0	0	0	1	0.005
YELLOW BULLHEAD	0	0	0	0	0	0	0	0	0	0	1	0	1	0.005
TOTALS	3910	1248	875	311	144	1236	1406	698	1310	2240	4175	699	18252	

Major Species

Alewife--

Introduction--Alewives were the most abundant species collected during 1979. In Lake Michigan, they were the second-most abundant species, representing 36.4% of the total catch (Table 13). In Pigeon Lake, alewives were second in abundance, representing 27.6% of the total catch (Table 18). Alewife numbers in Lake Michigan declined for the second consecutive year; 28,490 were collected in 1979, 44,617 in 1978 and 53,864 in 1977 (Jude et al. 1978, 1979a).

Seasonal distribution--

April--No alewives were caught in April. Adult alewives concentrate in deep water in Lake Michigan during winter months and migrate into shallower water in spring, usually by mid-April, depending on water temperature (Wells 1968). Temperatures in the study area during April ranged from 2.0 to 8.0 C which may have been too cold to initiate a shoreward migration by alewives. Few alewives were caught in April 1978.

May--Alewives had moved into the study area by May. Total catch for the month was 449 alewives. Highest catches were reported from night surface gill nets set in the area of the discharge. These were 183 at station L (6 m, south discharge) and 142 at station U (6 m, north discharge). Surface water temperatures at these stations were the warmest available, which may account for the higher concentration of alewives in the area. Higher catches may also reflect the influence of the discharge canal. Alewives have been observed spawning in the canal in 1978 and some evidence suggests a small resident population is present in the discharge canal the entire year (Jude et al. 1979a).

Bottom gill nets caught 87 alewives; the largest catch (49) was at station A (1.5 m, south) at night where surface water temperature was 14 C (Appendix 1), the warmest water available. Few alewives were taken in trawls (Appendix 7); of those caught, most were in the vicinity of the discharge. No alewives were collected in seines in Lake Michigan or in Pigeon Lake.

Only two alewives of those examined had well developed gonads; most had only moderate or slight development (Table 20). Spawning, therefore, had not yet begun.

June--In Lake Michigan, 1199 alewives were caught in June; only 1 alewife was collected in Pigeon Lake. More alewives were taken in June 1979 than in June 1978 when 566 were caught (Jude et al. 1979a). June 1977 sampling resulted in the collection of 2198 alewives (Jude et al. 1978).

Table 20. Monthly gonad conditions of alewives caught during 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. All fish examined in a month were included except poorly received specimens.

	Gonad condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Slight development		45	21	10	158	148	1	1	1
	Mod. development		40	78	31	28	5			
Males	Well developed			75	32	1				
	Ripe-running			7	1					
	Spent			13	22	14	27			
	Slight development		35	16	3	85	90			
	Mod. development		68	138	51	19	7			
Females	Well developed		2	171	82	8				
	Ripe-running			13	29					
	Spent			20	17	17	16			
	Absorbing			1	1	5				
Immature			4	23	27	202	248	415	916	111
Unable to distinguish			3	3	2	24	33	4	1	

Examination of gonad conditions showed that most alewives had well or moderately developed gonads, with some ripe-running individuals present (Table 20); spawning had apparently begun by this time. However, a lower percentage of ripe-running individuals in 1979 compared to June 1978 suggests that peak spawning was occurring somewhat later in 1979.

Most alewives (73%) were caught in gill nets in June (Appendix 7). Bottom gill nets at stations A (1.5 m, south) and B (3 m, south) had large catches, especially in day sets (191 and 166 alewives, respectively) (Fig. 12). Night surface gill nets also produced relatively large catches of alewives (Fig. 13). Night trawling resulted in the collection of alewives from all stations trawled (Fig. 14). Day trawls produced alewives only at depths of 6 m and less. Only one alewife was seined at night at beach station R (north discharge). High night catches in surface gill nets and higher day catches in bottom gill nets and trawls are consistent with observations by Brandt (1978) and Brandt et al. (1980) that alewives are demersally distributed during the day and move up into the water column at night.

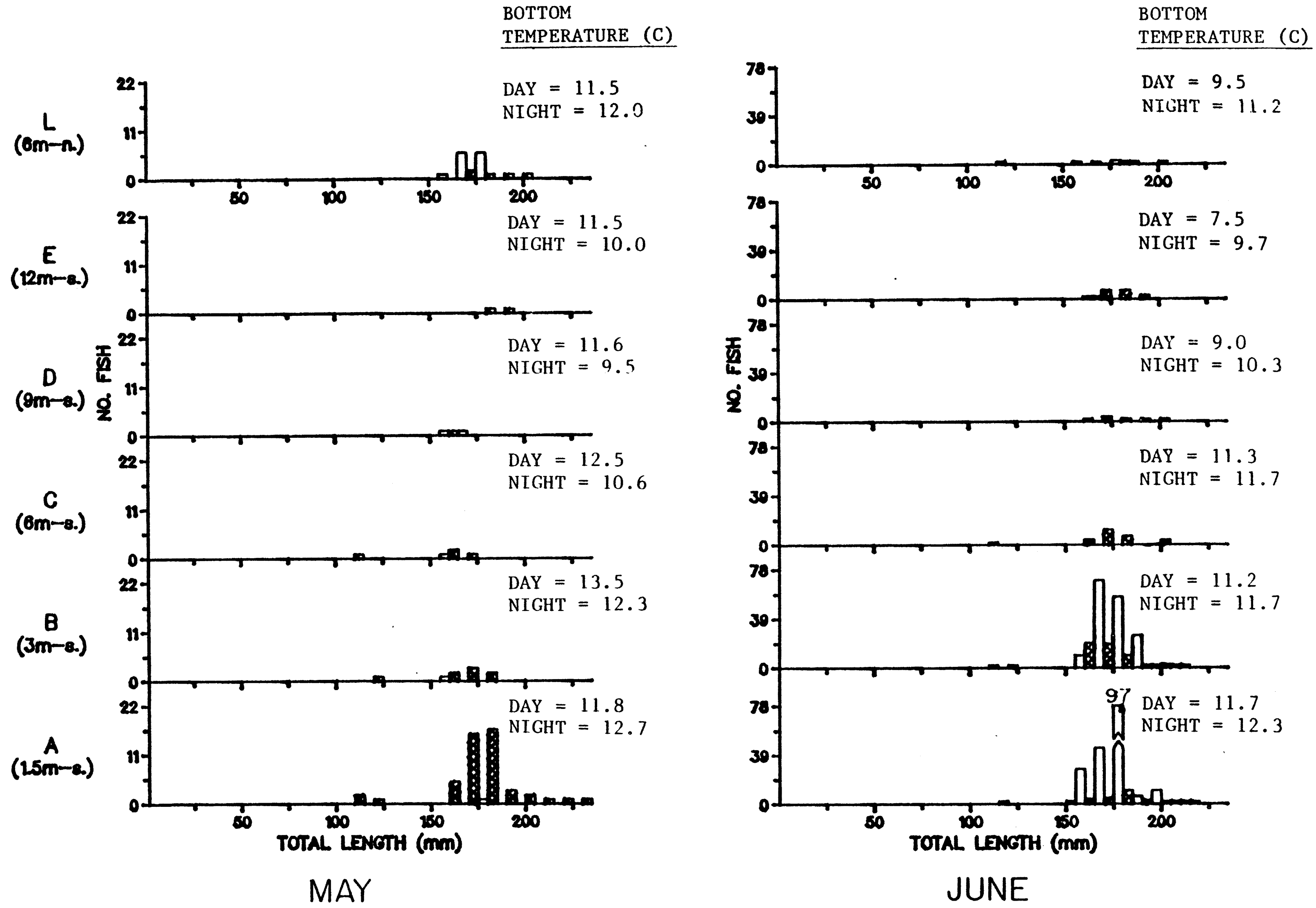


Fig. 12. Length-frequency histograms for alewives caught in duplicate bottom gill nets during April-November 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. □ = day ■ = night + = no sampling done

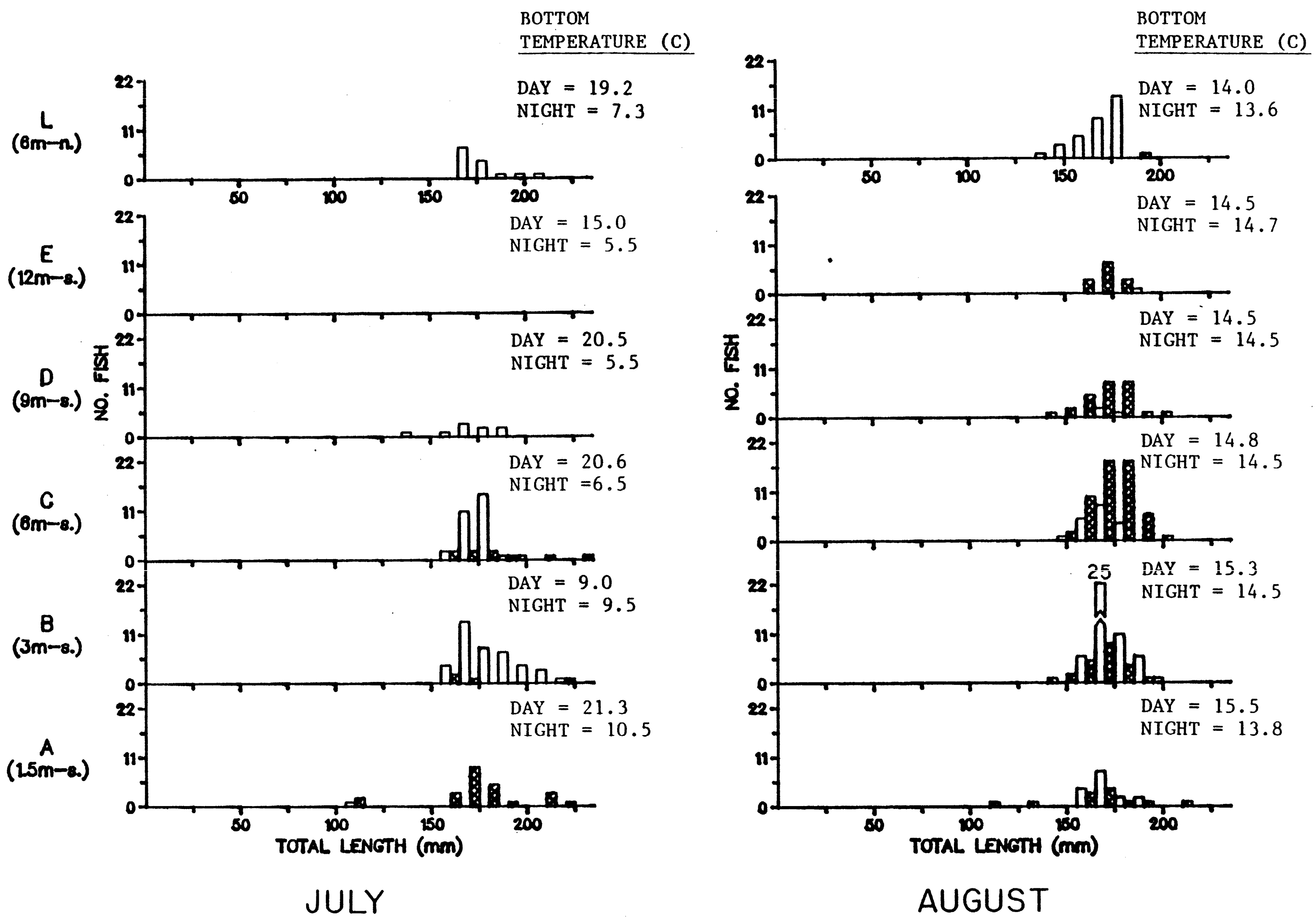


Fig. 12. Continued.

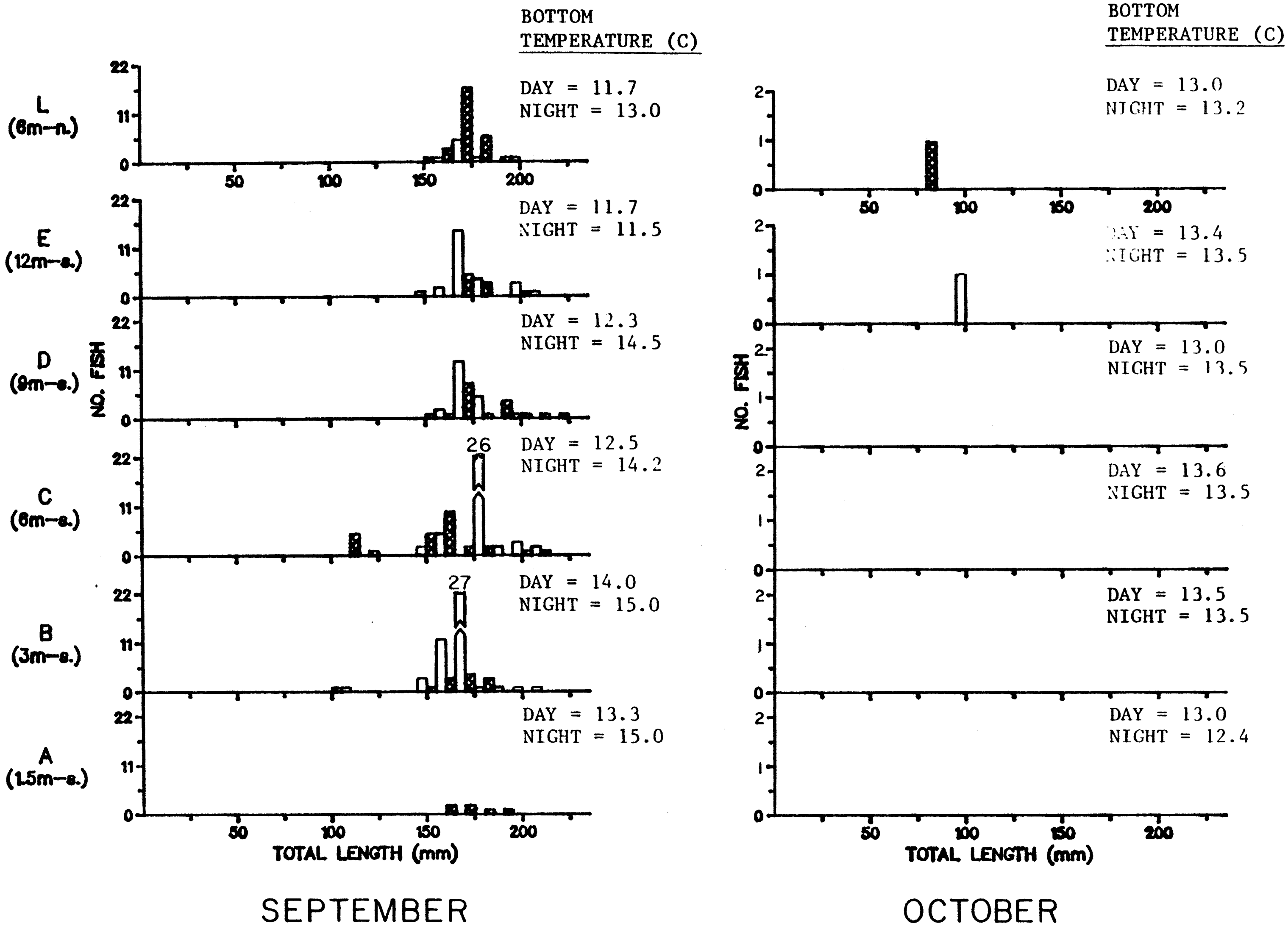


Fig. 12. Continued.

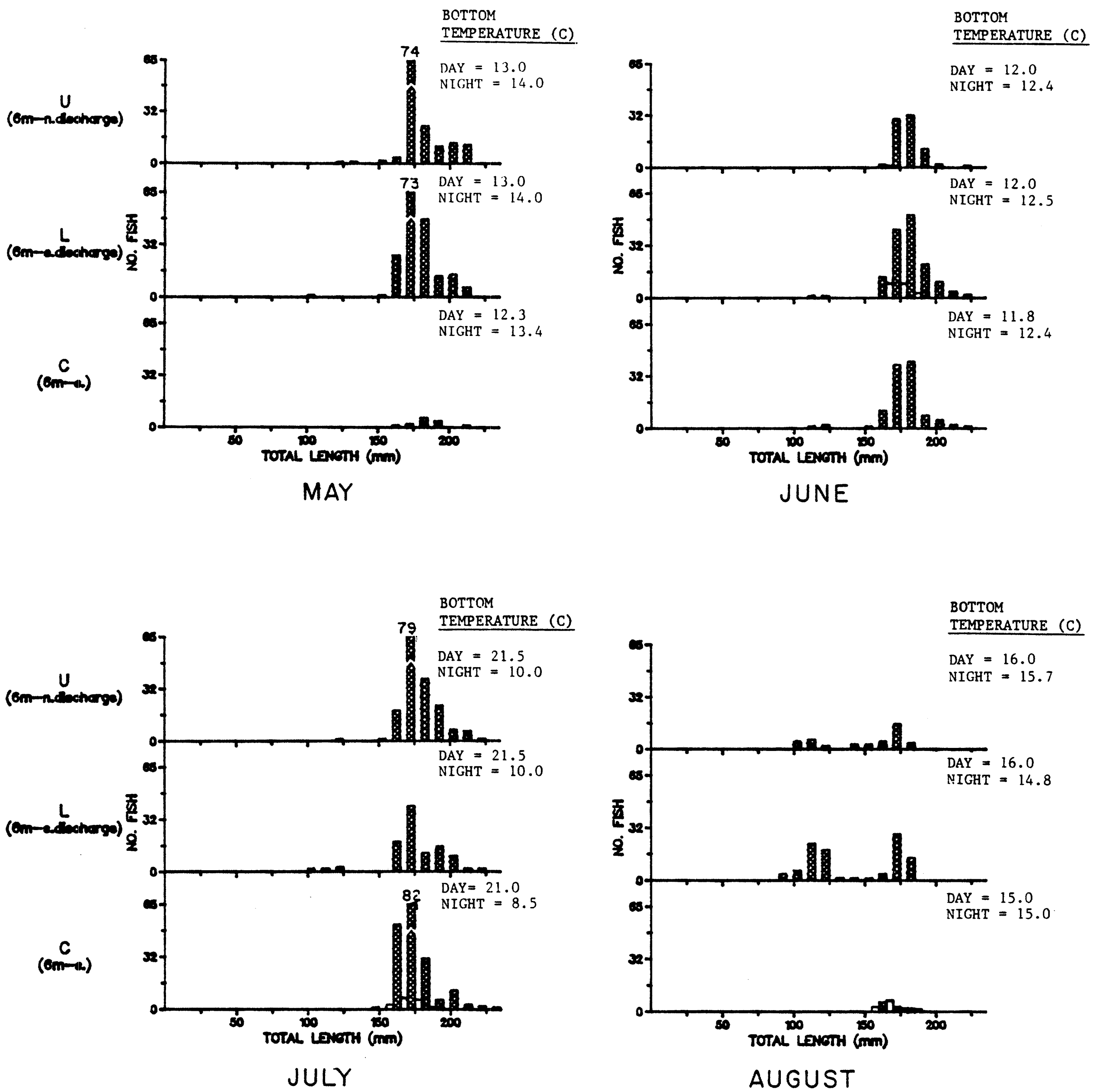
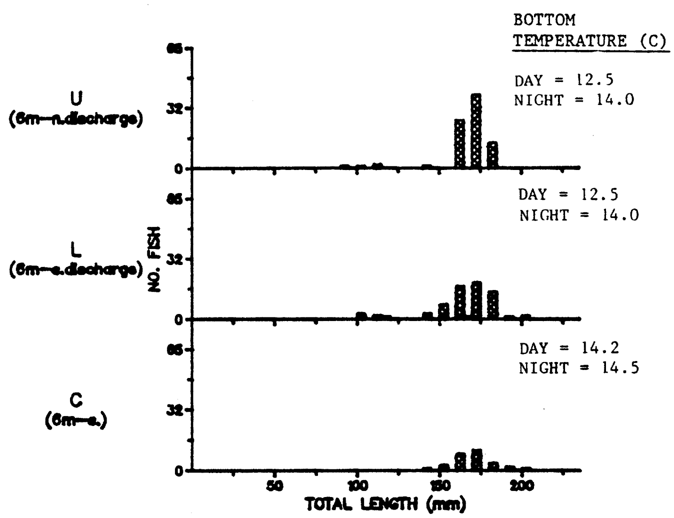


Fig. 13. Length-frequency histograms for alewives caught in duplicate surface gill nets during April to November 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. ☐ = day ■ = night



SEPTEMBER

Fig. 13. Continued.

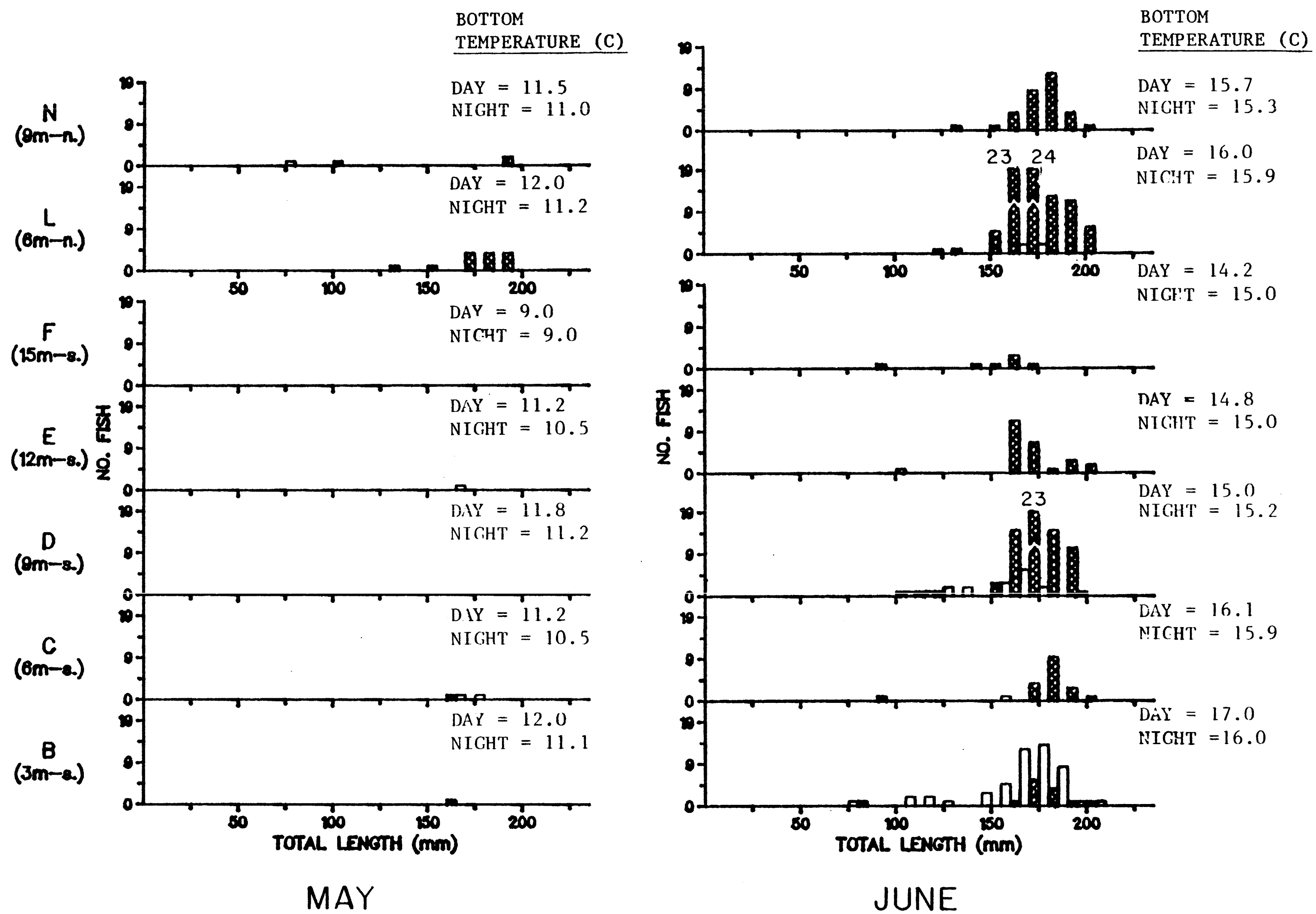
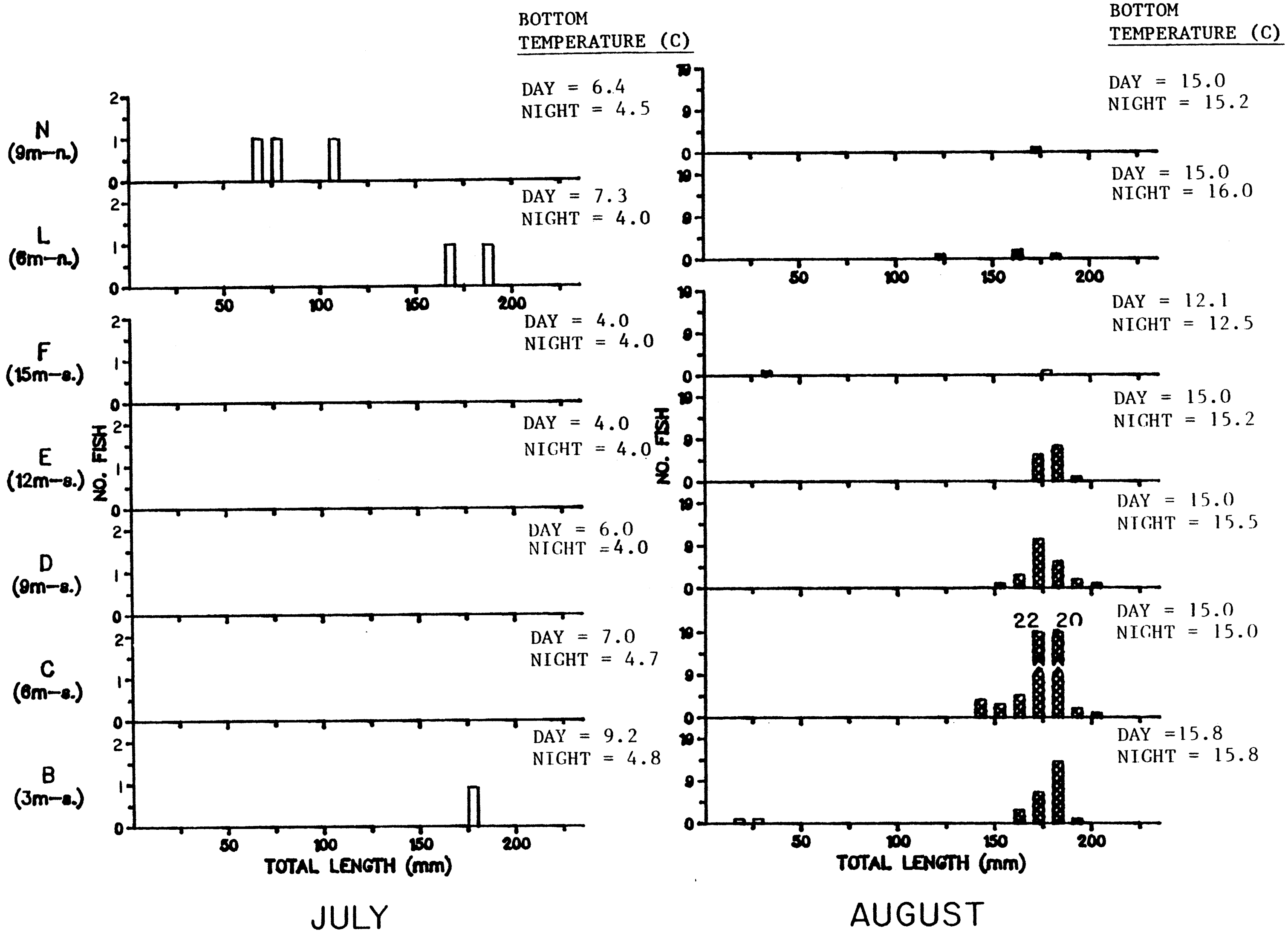


Fig. 14. Length-frequency histograms for alewives caught in duplicate trawl hauls during April to December 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan.
□ = day ■ = night * = no day sampling performed



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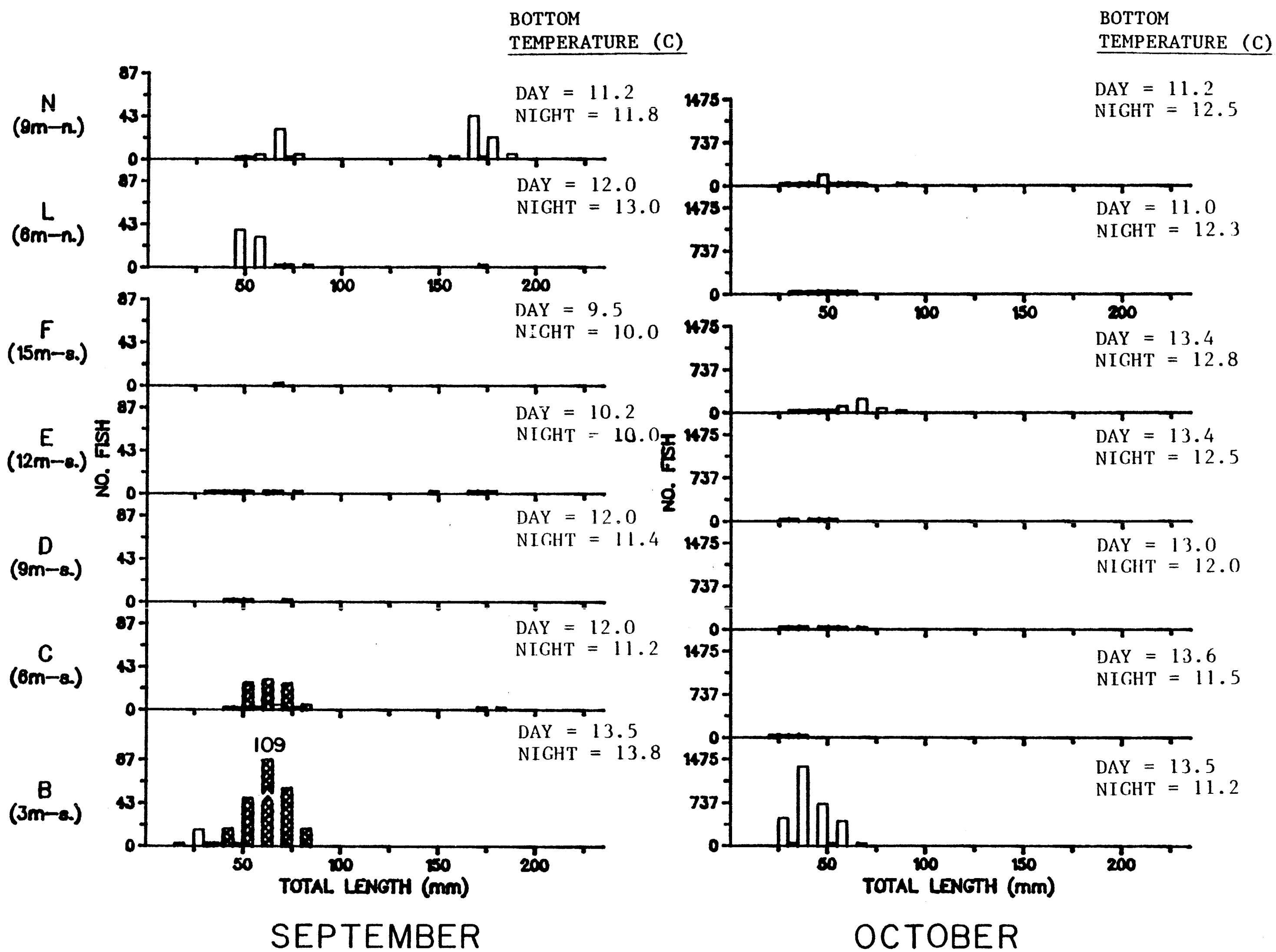

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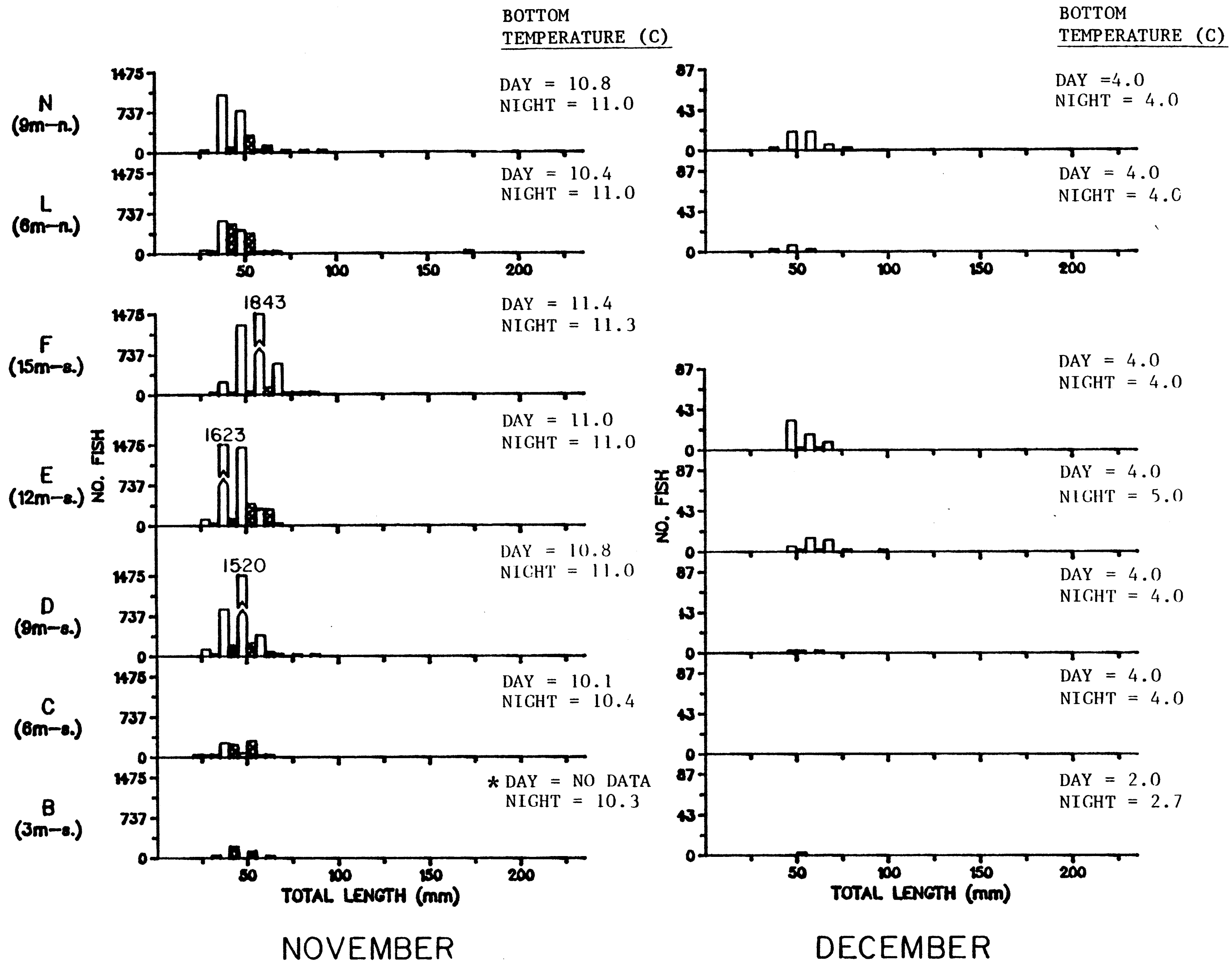


Fig. 14. Continued.

July--An upwelling occurred this month reducing water temperatures by as much as 10-15 C in Lake Michigan. Our sampling spanned the time of the upwelling and distributions of alewives reflected the changed thermal regimes. Fewer alewives were collected in July (677) than in June (1199). Alewives appeared to have left the area to avoid cold temperatures. After the upwelling, only surface gill nets had high catches of alewives (Figs. 13, 15). Beach seining and bottom gill nets at station A (1.5 m, south) collected moderate numbers of alewives (Figs. 12, 16). Again, these areas had warmest water temperatures available (Appendixes 1, 2 and 3). Only six alewives were taken by trawling, all in day trawls. None were taken at night when temperatures ranged from 4.0 to 4.8 C.

Examination of gonad conditions of alewives collected in July showed the presence of fish with well developed gonads as well as ripe-running and spent individuals (Table 20). Peak spawning appeared to be occurring at this time. No YOY greater than 25 mm were collected during any sampling this month. In 1978, spawning times and first appearances of YOY alewives were similar to 1979. In 1977, however, peak spawning was approximately 1 mo earlier and the first YOY alewives appeared in July. Earlier spawning in 1977 may have been a result of warmer temperatures early in the season (April and May). However, no sampling was done during those months in 1977, therefore, temperatures were not documented.

In Pigeon Lake during July, only one alewife was collected in a night seine at beach station S (influenced by Lake Michigan). Fewer adult alewives were collected in Pigeon Lake in 1979 than in 1978 (Jude et al. 1979a). Absence of adults in our samples is probably due to elimination of bottom gill nets at 6-m station M (influenced by Lake Michigan). Adults were collected more often in bottom gill nets than in seines in 1978 (Jude et al. 1979a).

August--YOY alewives were recruited to the seines for the first time this month in both Lake Michigan and Pigeon Lake (Appendix 6). Except for 3 YOY caught in trawls, all YOY alewife were collected in beach seines; 2155 in Lake Michigan and 4828 in Pigeon Lake. The highest catch in Lake Michigan was in day seines at beach station Q (south discharge) were 1669 alewives were collected. This concentration of YOY alewives could be a result of alewives spawning in the discharge canal followed by movement of young alewives out into the lake.

In Pigeon Lake during August, all seining except night seines at beach station S (influenced by Lake Michigan) resulted in large catches of YOY alewives. Spawning was apparently more successful in Pigeon Lake in 1979 than in 1978 when only 318 YOY were collected in August (Jude et al. 1979a). No adults were collected in Pigeon Lake in August. They had apparently moved into deeper water in Pigeon Lake or out into Lake Michigan after spawning.

Adult alewives were collected by all gear types in Lake Michigan, however, few were taken in day trawls or day surface gill nets (Appendix 7). All bottom gill net sets caught moderate numbers of alewives (Fig. 12) as did

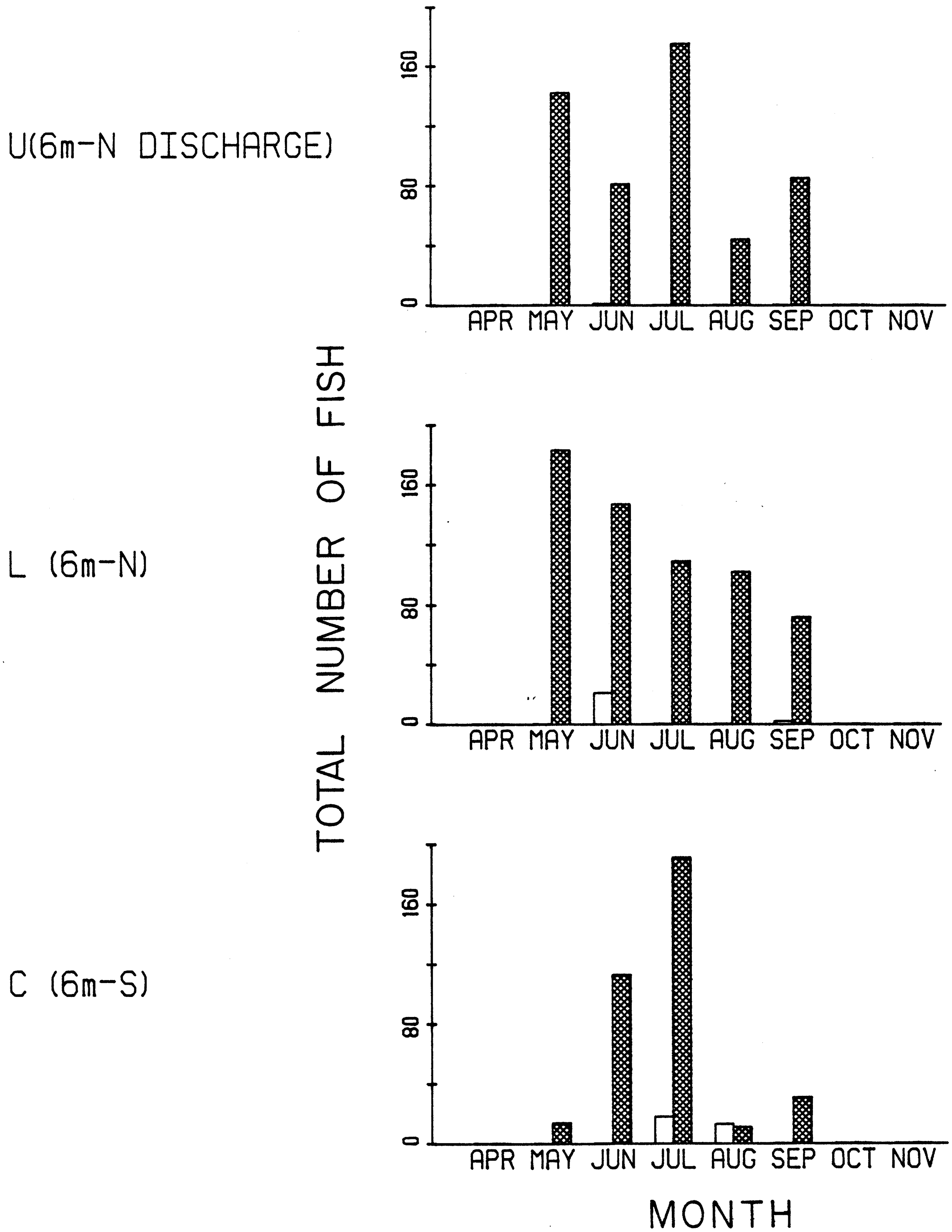


Fig. 15. Total number of alewives caught in duplicate surface gill nets fished during day and night once per month April to November 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. □ = day ■ = night

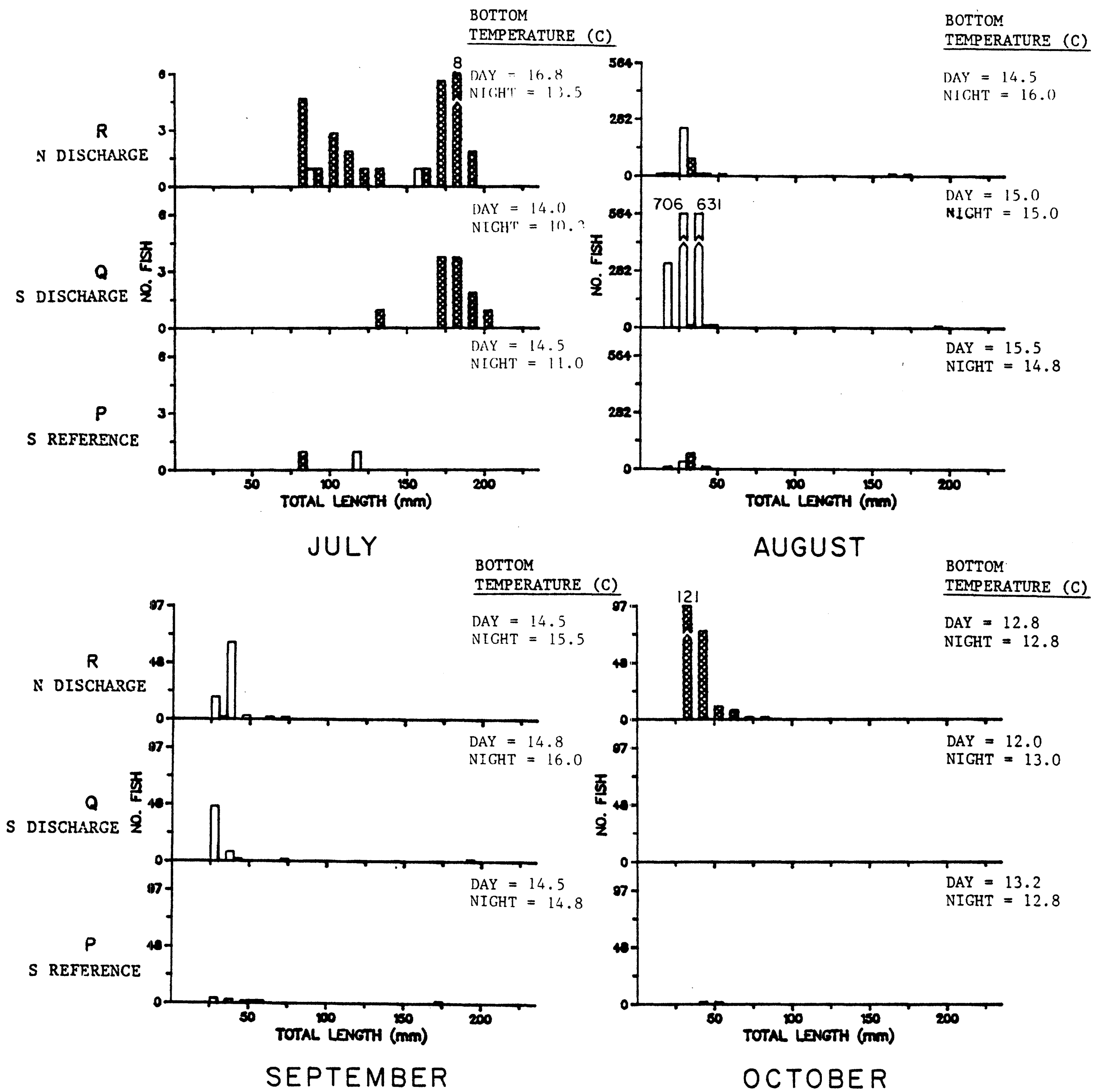


Fig. 16. Length-frequency histograms for alewives caught in duplicate seine hauls during April to November 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. □ = day ■ = night

night surface gill nets (Fig. 13) and night trawls (Fig. 14). The largest catch was 102 alewives in night surface gill nets at station L (6 m, south discharge).

Adults and YOY alewives appeared to be spatially segregated in August (Fig. 17). Adults appeared to inhabit the open water zone (6 m and deeper), whereas YOY alewives preferred the nearshore area (3 m and less).

Spawning was ending by August as examination of gonad conditions showed few fish with well developed gonads and no ripe-running individuals present (Table 20). Some alewives had spent gonads, but most had only slightly developed gonads.

September--In September, adult alewives still resided in our study area. Moderate numbers of adults were caught at all bottom gill net stations except day sets at station A (1.5 m, south) (Fig. 12). Surface gill nets at our three 6-m stations collected moderate numbers of alewives only at night (Fig. 13). Numbers of alewife YOY were down from August levels, especially catches in beach seines. Some YOY were collected in trawls at shallower depths. Trawling at 3-, 6- and 9-m stations collected some larger YOY, those in length intervals 50-80 mm. Small YOY appeared to be inhabiting the zone beyond the beach (and therefore out of range of beach seining), but somewhat shallower than the 3-m trawling station. Offshore movement by both adult and YOY alewife in September was also noted in 1977 (Jude et al. 1978) and 1978 (Jude et al. 1979a).

Larvae data (see FISH LARVAE AND FISH EGGS - Alewife) indicated the presence of newly hatched alewife larvae in late August and September. Spawning appeared to have been extended in 1979 compared to other years, perhaps as a result of the July upwelling which may have interrupted spawning.

In Pigeon Lake, 344 YOY alewives were collected. The largest catch (303) occurred in night seines at beach station V (undisturbed Pigeon Lake).

October--October catches of alewives were the second largest of the year (4259 fish) in Lake Michigan. Four YOY were collected in Pigeon Lake. All adult alewives appeared to have moved out of the study area by October. Consequently, gill net catches dropped substantially (only two fish were caught) as this gear is selective for larger alewives (Fig. 18). This trend of adults moving offshore in fall was also seen in 1977 and 1978.

Most alewives (93%) were collected in day trawl hauls (Fig. 18). A few fish were taken in night trawls. Only night seining at beach station R (north discharge) produced large numbers of alewives (218) in seines. These fish may be YOY that were spawned in the discharge canal and moved out into Lake Michigan north along shore, possibly with prevailing currents to beach station R (north discharge).

Largest catch was at station B (3 m, south) where 2980 YOY alewives were trawled (Fig. 14). In 1978 an interesting pattern was apparent in the distribution of YOY alewives (Jude et al. 1979a). During the day, smaller

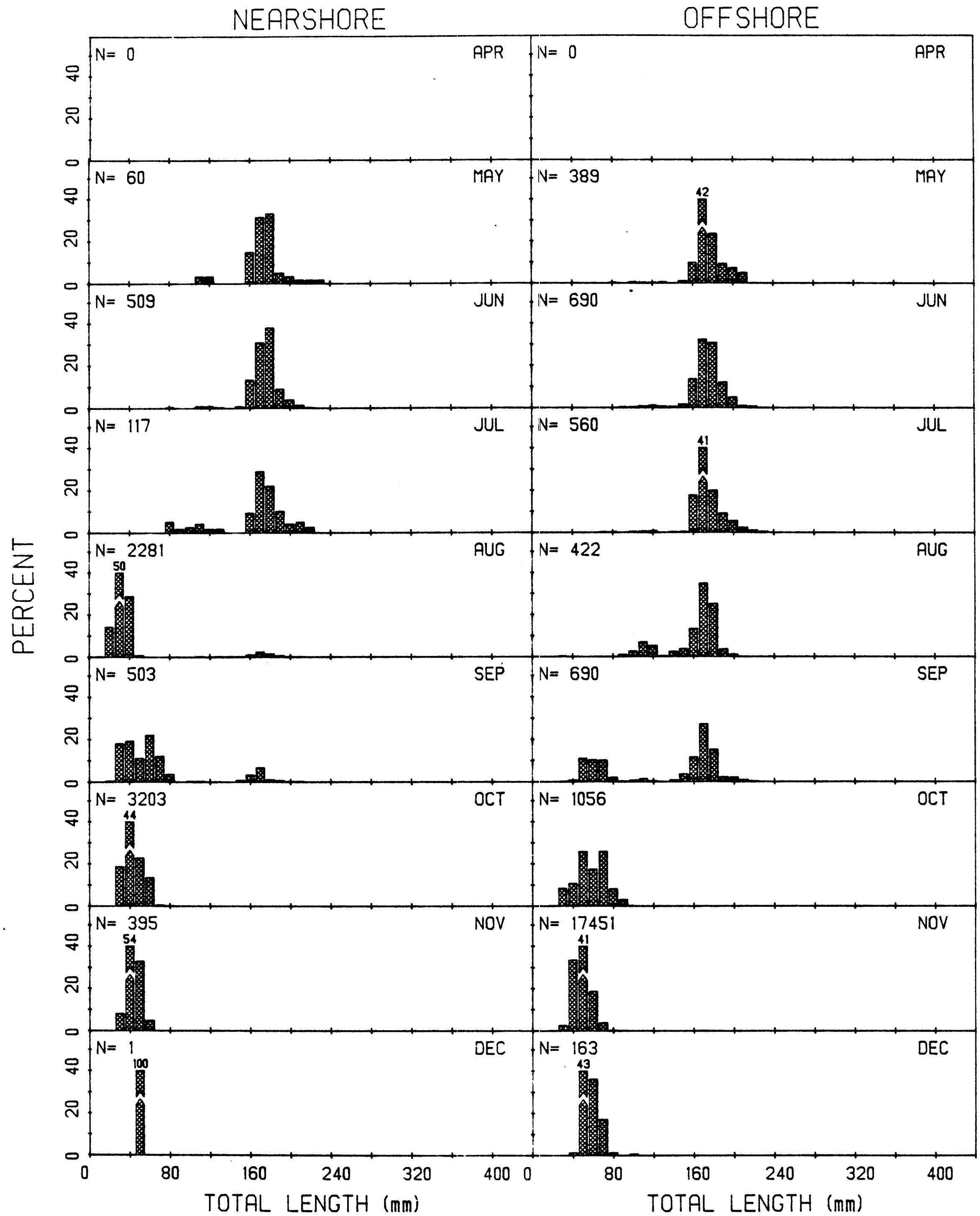


Fig. 17. Length-frequency histograms for alewives caught by all gear types at nearshore stations (beach, 1.5m, 3m) and offshore stations (6-15m) in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan, April to December 1979. N = number of fish.

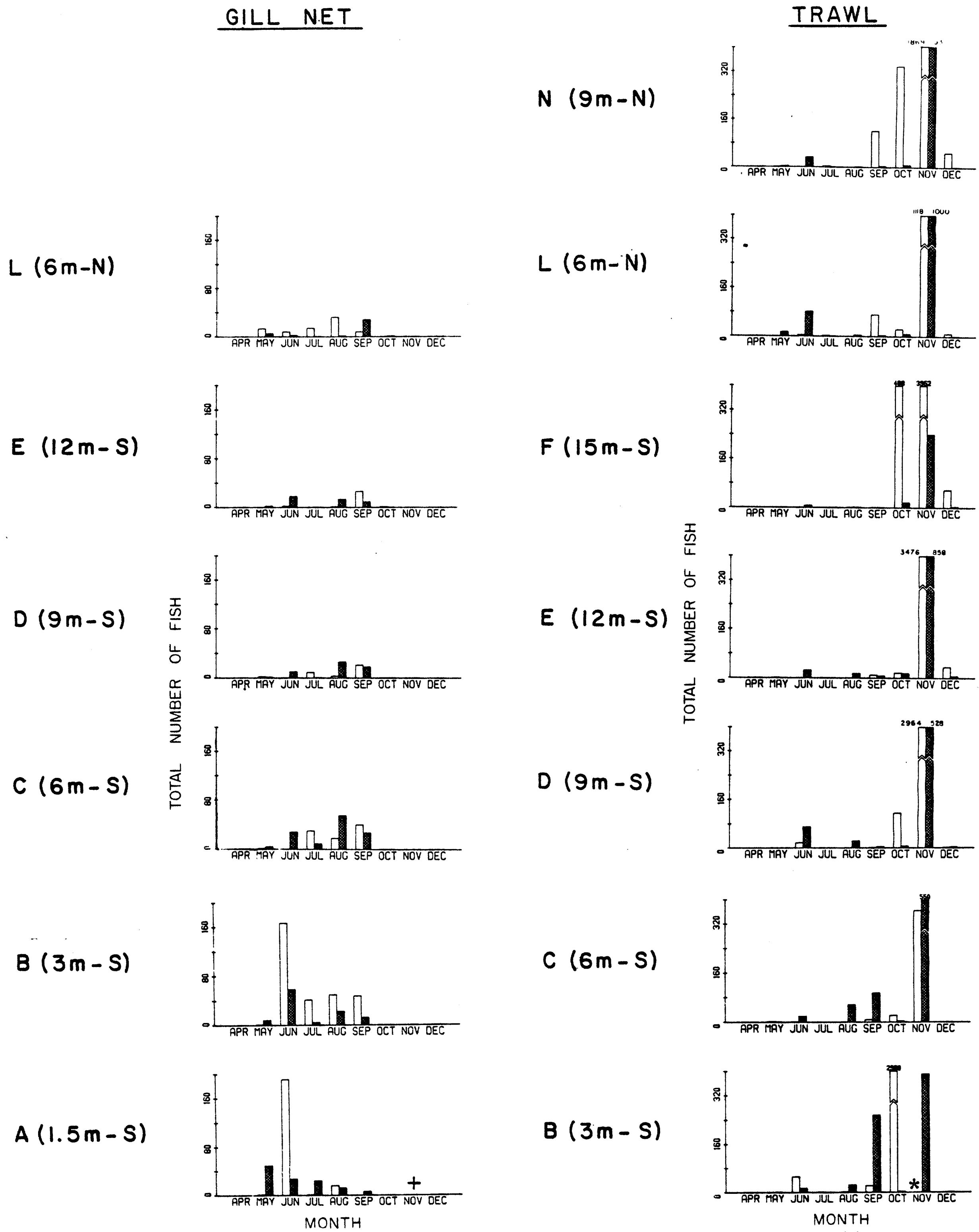


Fig. 18. Total number of alewives caught in duplicate bottom gill nets (left column) and duplicate trawl hauls (right column) during day and night once per month in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. Bottom gill nets were fished April to November 1979, trawl hauls were done April to December 1979. ☐ = day ■ = night * = no day sampling performed + = no sampling performed

alewives were collected nearshore with larger individuals caught in deeper water. At night, mean lengths of alewives caught at all sampling depths were very similar. Also, large catches were recorded at deeper stations during the day and in shallower water at night. These patterns are not apparent in 1979 alewife collections.

Very few alewives were caught in night trawls in October 1979 (numbers ranged from 3 to 17 fish per station). Some size-segregation existed in alewives taken from day trawls, but the trend was not as obvious as in 1978. The largest day trawl catch was at station B (3 m, south) where mean length of alewives was 44 mm. Station F (15 m, south) had the second largest catch of alewives, which had a mean length of 67 mm. Lower numbers of fish were collected at intermediate depth stations at the south transect (Fig. 14). At station N (9 m, north), 333 YOY alewives were collected; fish had a mean length of 54 mm. The low numbers of alewives caught at night made any comparison of mean length impossible. Differences between catch rates in day and night trawls may be due to vertical migration exhibited by alewives (Brandt 1978). With approaching darkness, alewives may have moved from the bottom and into the water column, making them less susceptible to trawling while still remaining in our study area.

November--This month's sampling produced the largest catch of alewives of 1979 with 17,846 fish collected. This total number is down from November 1978 when 26,846 were collected. Of this month's catch, only one was an adult, the rest were YOY.

No alewives were collected in Pigeon Lake. In 1977 and 1978, alewives also appeared to have moved out of Pigeon Lake by November. Either alewives do not overwinter in Pigeon Lake, or they move into deeper areas of the lake which are not sampled.

All alewives, except for five fish collected in seines, were taken in trawl hauls (Fig. 14). Day trawls at station B (3 m, south) were not done due to rough seas. Day trawls accounted for 77% of alewives collected; the largest catches were from 9- to 15-m stations (Fig. 18). No clear trends in size distributions were evident, nor was there a distinct inshore movement at night as was seen in 1977 and 1978. Turbulent water and a rough surf zone, a result of high winds, may have kept alewives from moving as far inshore as they might have in calmer weather. Water temperatures between day and night sampling were not appreciably different, eliminating temperature as a directing factor in alewife distributions. The lower overall catches at night may again be a result of vertical migration up in the water column.

December--Catches of alewives this month were down significantly from November. Only trawling was performed which resulted in the capture of 164 YOY alewives. Most were taken at deeper stations (Fig. 14). By December, most alewives had moved offshore into deeper water for winter.

Temperature-catch relationships--In Lake Michigan, 98% of all alewives collected were caught when mean water temperatures were 10-16 C. The range of temperatures at which alewives were collected was 2-22 C. In contrast to 1977 and 1978, no appreciable difference was noted in temperatures at which adults were found when compared to temperatures recorded when YOY were collected. The range of temperatures available to alewives in our study area was not as extensive as in previous years, i.e., water temperatures did not get as warm (Fig. 19). YOY alewives seem to prefer warmer temperatures than adult alewives (Jude et al. 1978, 1979a; Otto et al. 1976). Had warmer temperatures been more available in 1979, more complete temperature preference data may have been obtained.

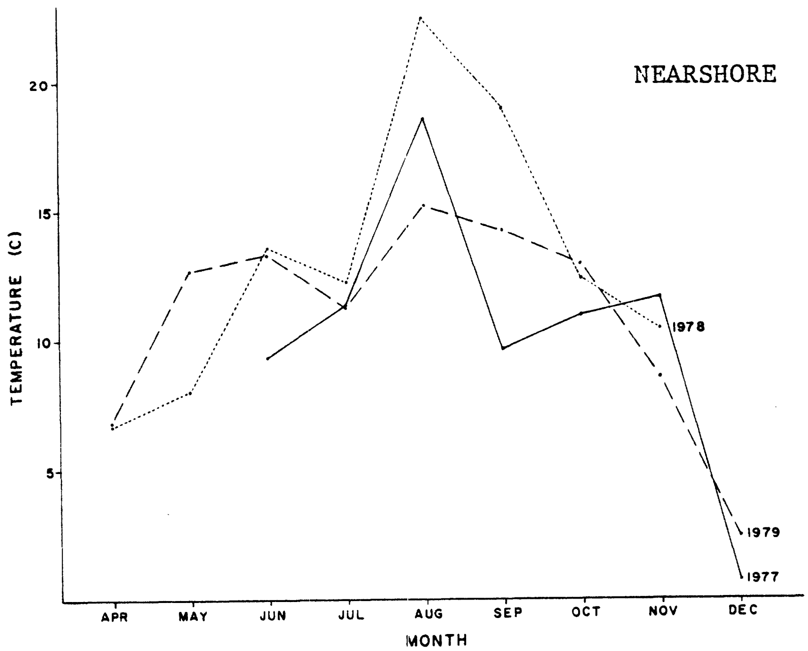
Impingement--During 1979, 9920 alewives were collected in impingement samples taken at the Campbell Plant (see IMPINGEMENT). Expanding this number to an estimated total impingement of alewives results in a total of 71,372 alewives impinged at the Campbell Plant in 1979 (see IMPINGEMENT). Alewife impingement was highly variable throughout the year ranging from no fish collected in a 24-h period to a maximum of 1422 per 24-h period.

YOY alewives were collected in January and February impingement samples. A source other than Pigeon Lake was likely for these alewives because late fall field sampling in Pigeon Lake indicated that alewives had left the lake as winter approached. Some alewives (and other species such as gizzard shad and quillback) appear to reside in the discharge canal the entire year. They gain access to the intake forebay during winter months via a gate connecting the discharge forebay with the intake forebay and are therefore susceptible to impingement.

Only one alewife was collected in March samples and none in April. In late May, adults began to appear in impingement samples. This occurrence corresponds with beginnings of inshore movement of alewives for spawning. Gonad data (Table 21) indicated that most alewives had moderately developed gonads, but some did have well developed gonads.

Late June and early July samples had the highest numbers of adult alewives present (Appendix 8). Field sampling indicated peak alewife spawning in June and July in Lake Michigan, and presence of large numbers of adult alewives in impingement samples suggests a large number of alewives moved into Pigeon Lake to spawn. Numbers of adults collected diminished by the end of July. Very few adults were observed in August samples.

YOY alewives first appeared in late August samples. August field sampling in Pigeon Lake resulted in the largest numbers of YOY alewives collected in 1979. Relatively large numbers (ranging from 19 to 446 fish) of YOY were collected in impingement samples throughout September and early October. In late October, 1294 YOY were collected in one 24-h sampling. Lake Michigan field sampling showed that YOY moved offshore in October. Pigeon Lake YOY may also have moved into deeper water, possibly being attracted to currents in the intake canal. Entering the intake canal would make them more vulnerable to impingement.



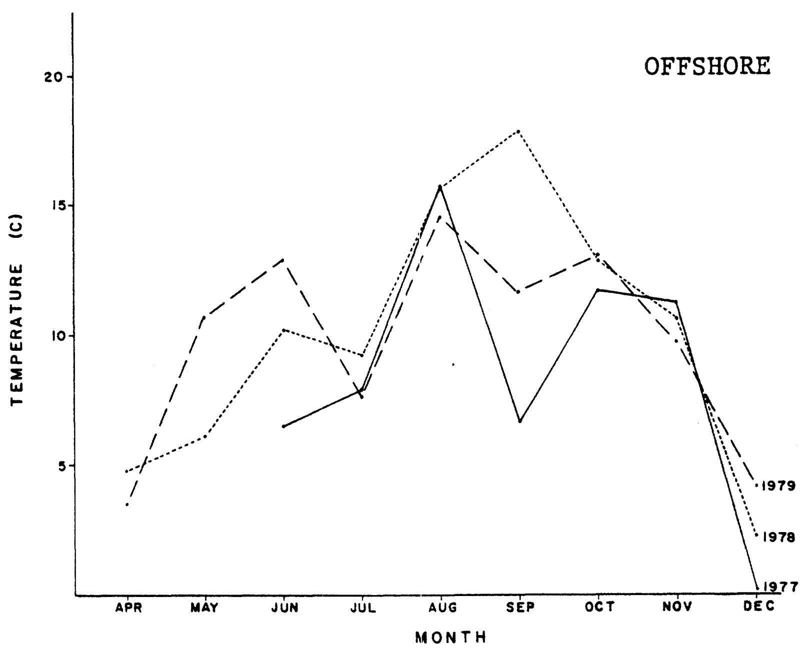


Fig. 19. Mean water temperatures at nearshore stations (beach, 1.5m, 3m) and at offshore stations (6-15m) in Lake Michigan taken once per month April to December in 1977, 1978 and 1979.

Table 21. Monthly gonad conditions of alewives collected in impingement samples during 1979 at the J. H. Campbell Plant, eastern Lake Michigan. All fish examined in a month were included except poorly received specimens.

	Gonad condition	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Slight development	6	2	1		8	46	96	32		2		1
	Mod. development					13	35	40	3				
Males	Well developed					2	8	5					
	Ripe-running												
	Spent					2	24	8					
	Slight development	1				4	28	38	8	2	1		
	Mod. development		1			14	48	88	5				
Females	Well developed					7	44	28	1				
	Ripe-running												
	Spent					2	22	11					
	Absorbing					1	6						
Immature		108	60			5	9	28	178	249	268	422	162
Unable to distinguish		1	1			4	9	10	8	5		4	3

YOY alewives in large numbers (370-1422 fish per 24 h) were observed in November impingement samples. Appearance of many YOY alewives corresponds with the opening of the gate between the discharge and intake forebay. These alewives were probably residing in the discharge canal. YOY alewives were also impinged in December although in lower numbers than in November. From 18 to 146 alewives were collected per 24-h sampling period.

Plant impacts--Alewives were the most frequently impinged species at the Campbell Plant with an estimated 71,372 juvenile and adult fish impinged during 1979. In 1978, an estimated 45,722 fish were impinged. However, a comparison between estimated numbers of alewives impinged in 1979 (71,372) and an estimated 1978 population of alewives in the southern basin of Lake Michigan (497 million - Brandt 1978) reveals that impingement at the Campbell Plant represents 0.01% of the southern basin population.

Larval alewives were also the most frequently entrained species with 23.4 million larvae entrained in 1979. This number is lower than the number (48.9 million) entrained in 1978. Production foregone estimates from 1978

data suggested that losses due to entrainment represented a small part of the potential harm to the Lake Michigan alewife population (Jude et al. 1979a). Hence, we feel that entrainment losses in 1979 also represented a small impact on the total population.

Other considerations--Alewife populations in eastern Lake Michigan appear to have declined over the last 3 yr. Numbers of alewives collected in our field samples have steadily decreased from 1977 when 53,864 were collected (this number represents catches only from June through December) to 28,490 collected in 1979 (April-December). Cold winters or predation by salmonids in Lake Michigan may be reasons for this population decline. Alewife populations are characterized by cyclic fluctuations in abundance. With increased stocking rates of salmonids and therefore, increased predation of forage species, the cycling exhibited by alewife populations may bring them to a level where predation rates may have a significant impact (D. J. Stewart, personal communication, Field Museum of Natural History, Chicago, Illinois).

If alewife populations were declining, an increase should be seen in competitive species. Such a trend has been shown for catches of unidentified coregoninae. In 1977 they represented 0.6% of the total catch, whereas in 1979 they represented 7.0%. These changes in coregonid abundance are confounded by concurrent elimination of commercial fishing on the species in Michigan. (For further discussion of this group of fishes, see ADULT AND JUVENILE FISH, Unidentified Coregoninae.)

Summary--No alewives were collected during April in Lake Michigan or Pigeon Lake. In May, adult alewives began moving into our study area, although gonad data indicated that spawning had probably not yet begun. By June, spawning had begun and more alewives moved into the inshore area.

Spawning appeared to peak in July. However, an upwelling which occurred in the midst of our sampling effort resulted in movement of most adult alewives out of our study area. YOY alewives were first collected in August in both Lake Michigan and Pigeon Lake. Most YOY were inshore and were collected in beach seines. Adults were still present in the study area, although gonad data indicated that most spawning was over by mid-August.

In September, YOY were beginning to move offshore with fewer caught in beach seines and some caught in trawls at shallower depths. Adults were still present in the area. By October, adult alewives had moved out of our study area. YOY had moved farther offshore and were caught primarily in trawls. November sampling produced the largest catches of alewives for the year; all but one were YOY and most were caught in trawls. Largest catches were taken from 9- to 15-m stations indicating continuing movement offshore by YOY. By December, all but a few YOY alewives had moved offshore into deeper water and out of our study area.

No apparent relationship was evident between water temperature and size of alewives, although in previous years, some temperature preference by size was seen. Lack of this type of relationship could be due to the narrower range of water temperatures available to alewives in 1979.

Rainbow Smelt--

Introduction--Rainbow smelt is a marine species native to the Atlantic coastal drainage. Smelt populations in the Great Lakes were believed to originate from a planting in Crystal Lake, Michigan in 1912 (Van Oosten 1937). From Crystal Lake, rainbow smelt quickly spread to Lake Michigan and other Great Lakes where they reached very high levels of abundance. Several studies have been made on the biology of smelt and their impacts on fish populations of the Great Lakes (Creaser 1925; Van Oosten 1940; Hale 1960; Gordon 1961; Bailey 1964). Rainbow smelt is an important commercial species. They are also caught by dipnet sportfishing during their spawning run. Rainbow smelt populations in Lake Michigan, as indicated by commercial catches, fluctuated widely during the period 1931-1972 (Wells and McLain 1973). This species is more abundant in northern Lake Michigan than in the southern portion of the lake. Near the Campbell Plant, rainbow smelt was one of the most abundant species collected in Lake Michigan during the period 1977-1979. Only small numbers of smelt were found in Pigeon Lake.

Seasonal distribution - Lake Michigan--

April--Rainbow smelt migrate from deep water to shallow areas of lakes or into tributary streams to spawn during spring. In Lake Michigan, spawning usually takes place during April and May (Daly and Wiegert 1958; Van Oosten 1940). In 1978, smelt spawning was in progress in our study area during the April sampling trip (24-27 April). During 15-17 April 1979, only 12 adult smelt (120 mm and larger) were collected. Of these, eight were gillnetted in water 1.5 to 9 m deep (Figs. 20, 21) and four were trawled at 6 and 9 m. Substantially higher numbers of adults (450) were caught during April 1978. Only a few of the adults collected during April 1979 showed well developed or ripe-running gonads; no spent adults occurred in April 1979 samples. Low catches of smelt in spawning condition and absence of spent individuals (Table 22) suggested that no major spawning run had taken place before or during our April sampling trip. In Lake Michigan, rainbow smelt start to spawn only when water temperature reaches at least 4.5 C in the spring (Daly and Wiegert 1958). Peak spawning occurred when water temperature increased to 10 C (Jude et al. 1975; Euers 1960). Scarcity of spawning in the study area during 15-17 April may be due to the water being too cold in the inshore area. Water temperatures during the sampling period were only from 2.9 to 6.5 C.

Yearlings (40-100 mm), like adults, move inshore during spring. In Lake Superior, most yearlings were caught in water less than 15 m during spring (Dryer 1966). Yearlings were found in substantial numbers in our study area during April. A small number of yearlings were caught in night seines at beach station Q (south discharge) and beach station R (north discharge) (Figs. 22, 23). They occurred in night trawls towed at 3 to 15 m and were most common at 9 m (Figs. 20, 24). Day catches of yearlings were highest at 15 m. A low number of yearlings also occurred from 3 to 12 m during the day (Fig. 24). This concentration of yearlings at deeper stations was also observed during April 1978. More yearlings were caught at night than during the day in April 1978 and 1979. Due to discharge of heated water, night water temperature (10.5 C) at station Q (south discharge) was substantially higher

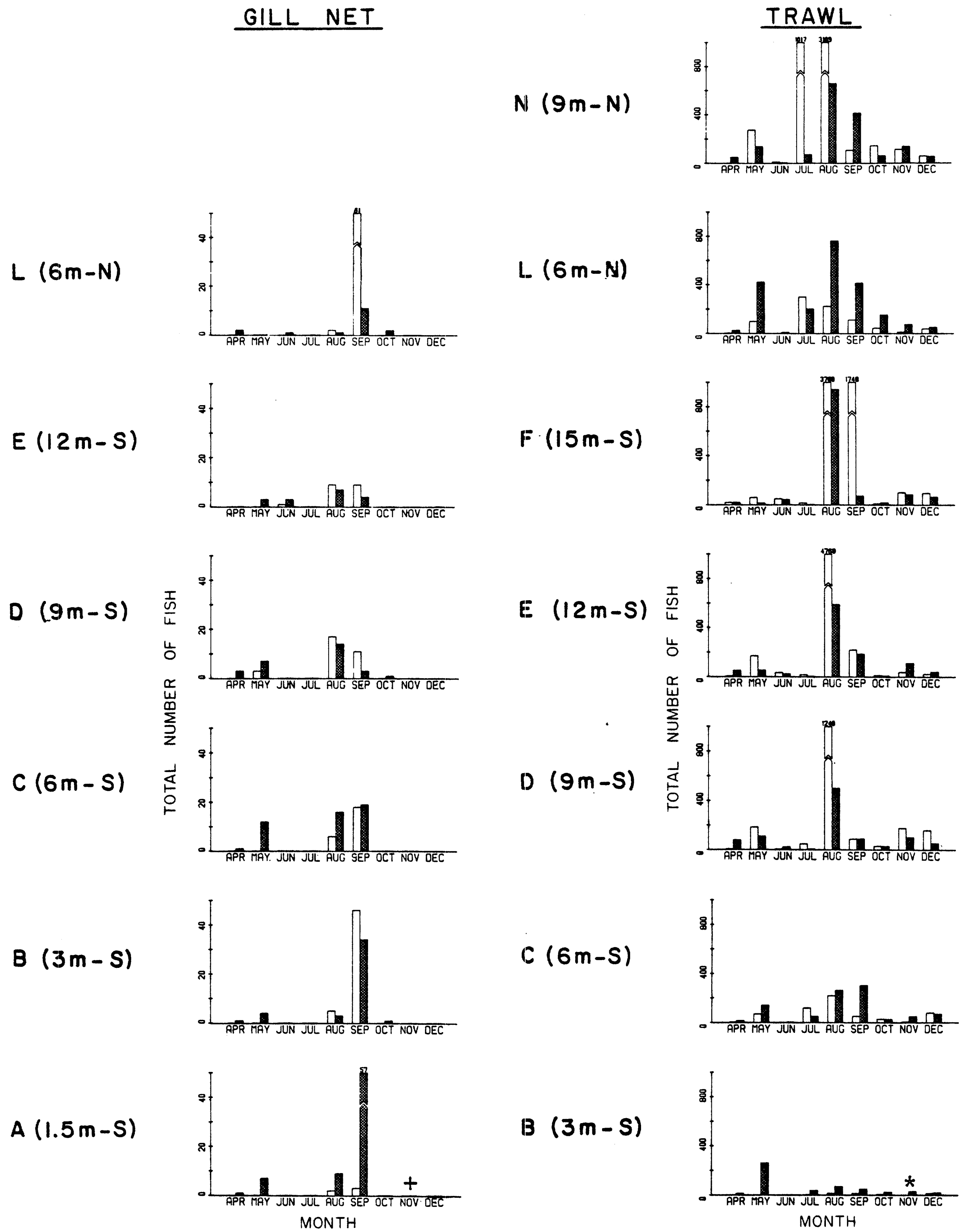


Fig. 20. Total number of rainbow smelt caught in duplicate bottom gill nets (left column) and duplicate trawl hauls (right column) during day and night once per month in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. Bottom gill nets were fished April to November 1979, trawl hauls were done April to December 1979. □ = day ■ = night * = no day sampling performed + = no sampling performed.

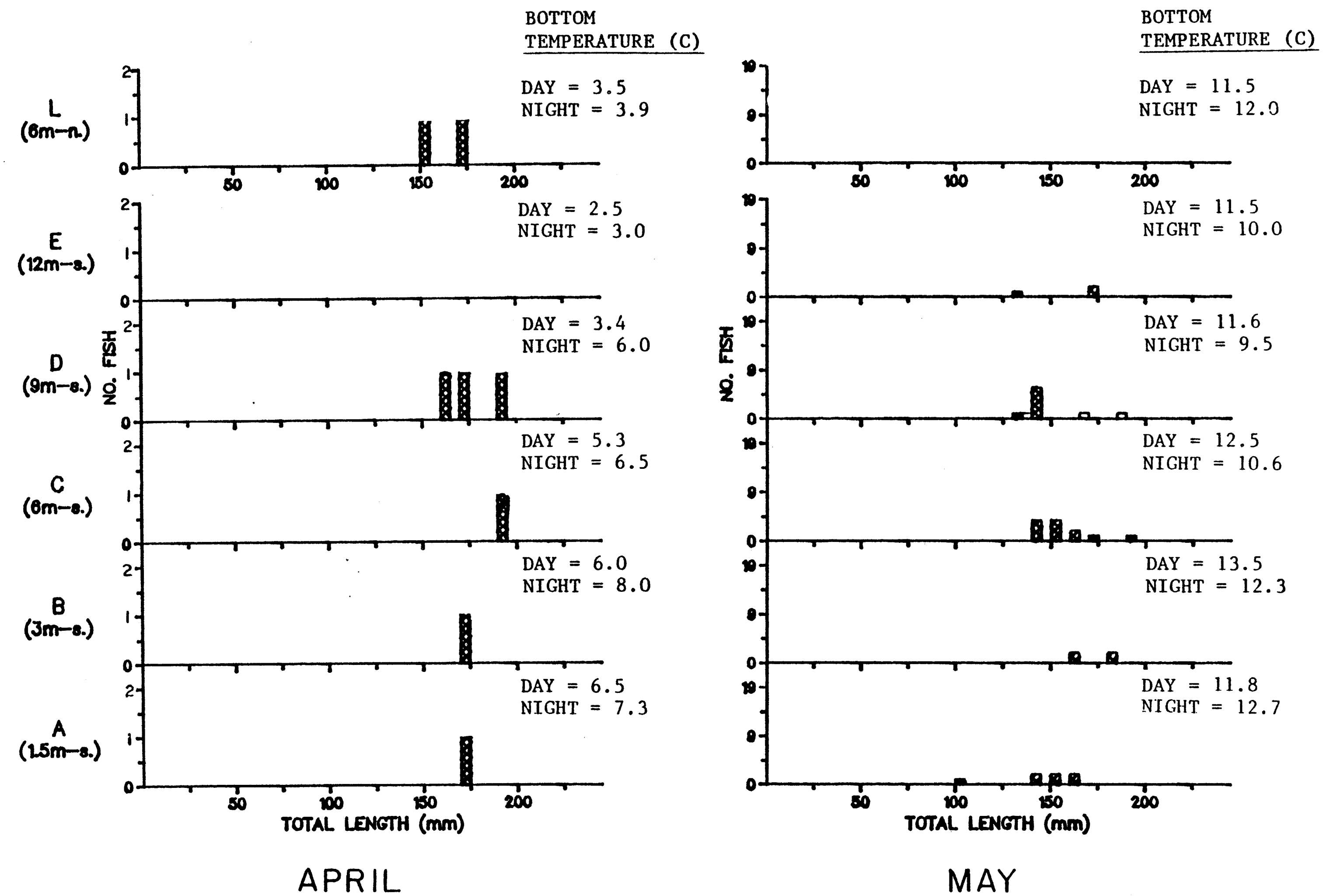
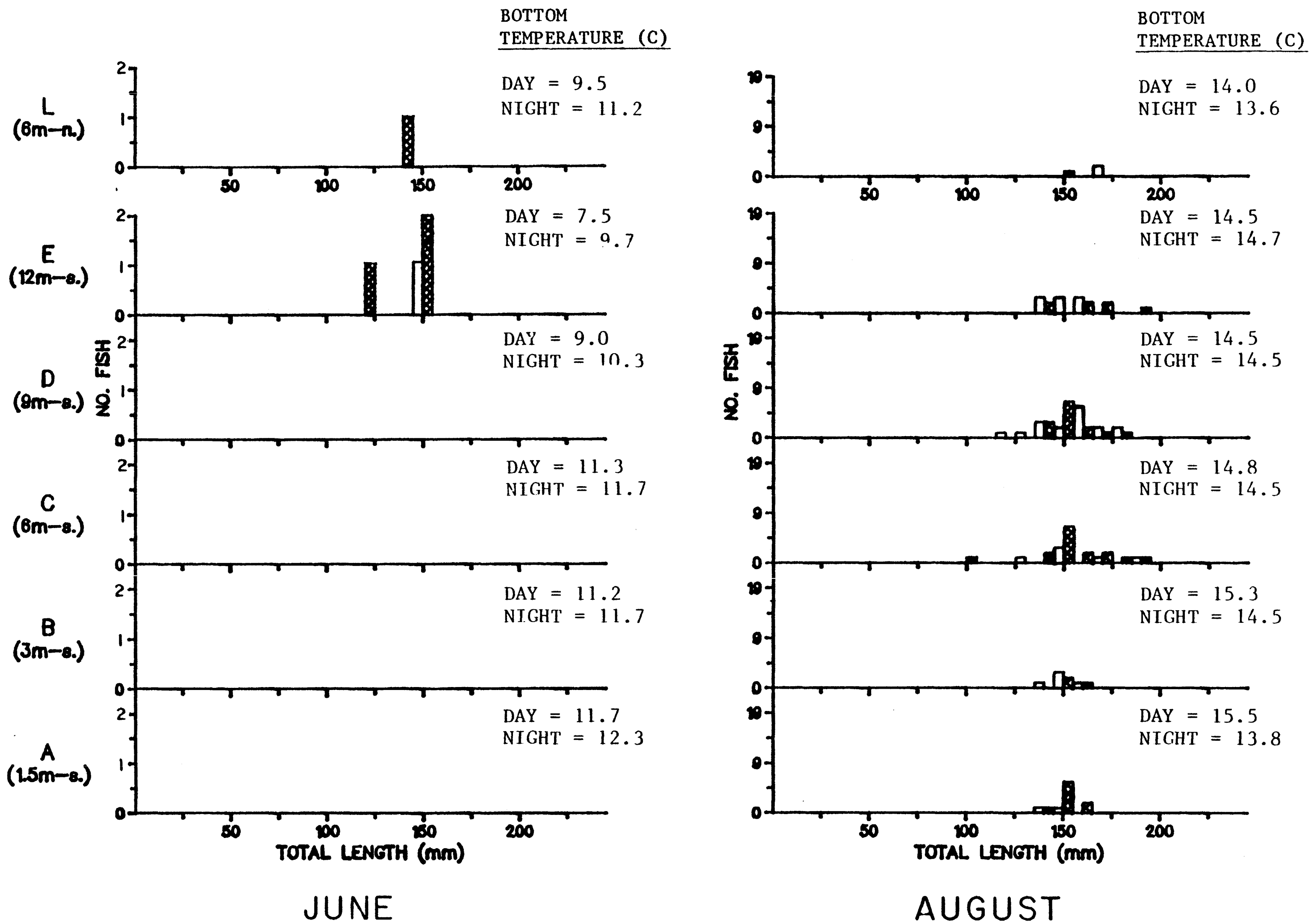


Fig. 21. Length-frequency histograms for rainbow smelt caught in duplicate bottom gill nets during April-November 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. □ = day ■ = night + = no sampling performed.



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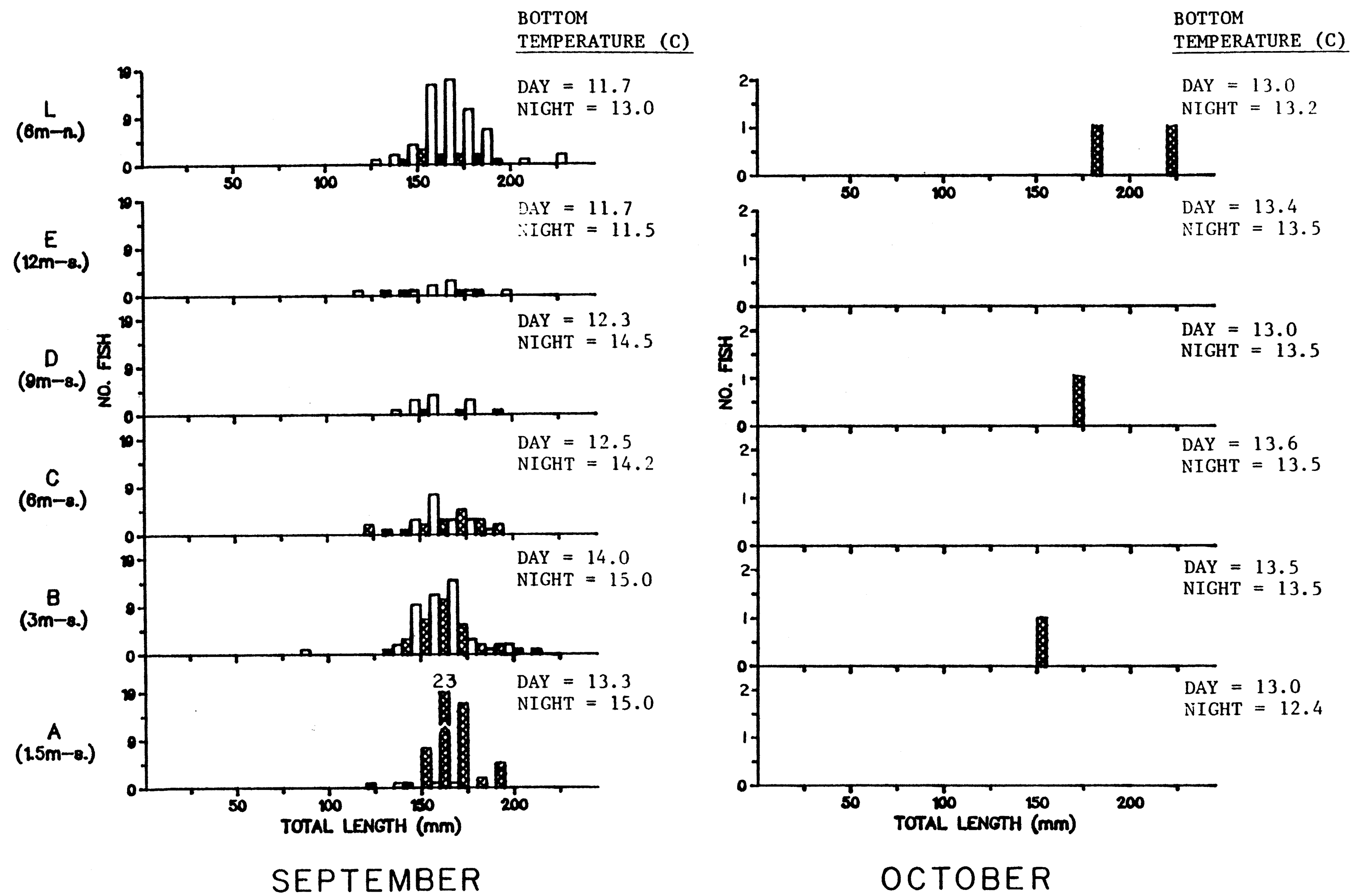


Fig. 21. Continued.

Table 22. Monthly gonad conditions of rainbow smelt caught during 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. All fish examined in a month were included except poorly received specimens.

	Gonad condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Males	Slight development	1	46	1	46	115	213	13		3
	Mod. development	2	3		8	19	61	1		4
	Well developed	1	4				3			
	Ripe-running	1	1							
	Spent		2	1						
Females	Slight development		8	2	23	40	63	4		
	Mod. development		2		1	2	11			11
	Well developed	5	18							
	Ripe-running	2	2							
	Spent		3							
	Absorbing				1					
Immature		241	1002	175	500	571	605	328	383	446
Unable to distinguish			57	5	46	75	96	11	1	4

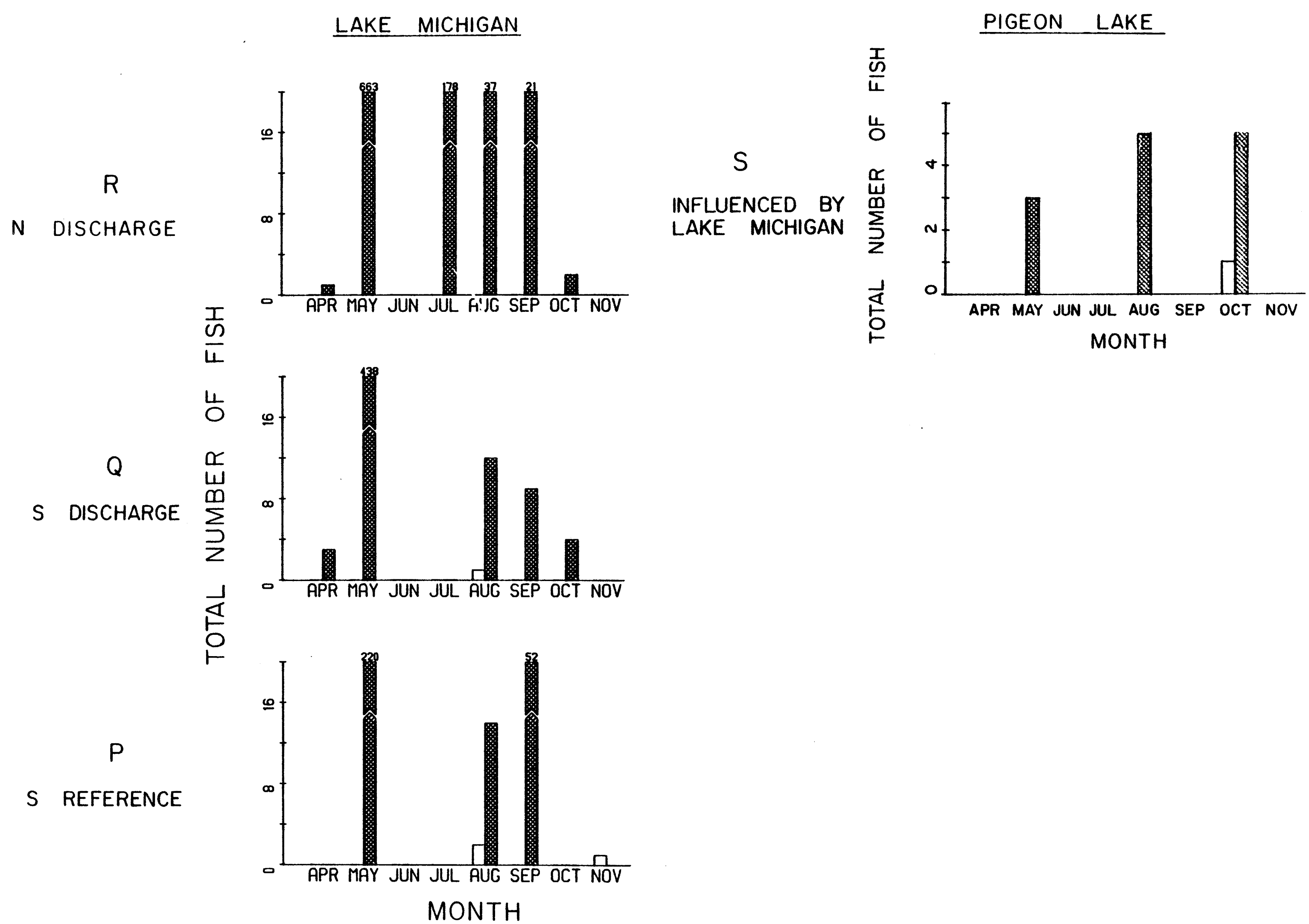


Fig. ' 22. Total number of rainbow smelt caught in duplicate seine hauls during day and night once per month April to November in Lake Michigan and Pigeon Lake near the J. H. Campbell Plant, eastern Lake Michigan. ☐ = day ■ = night.

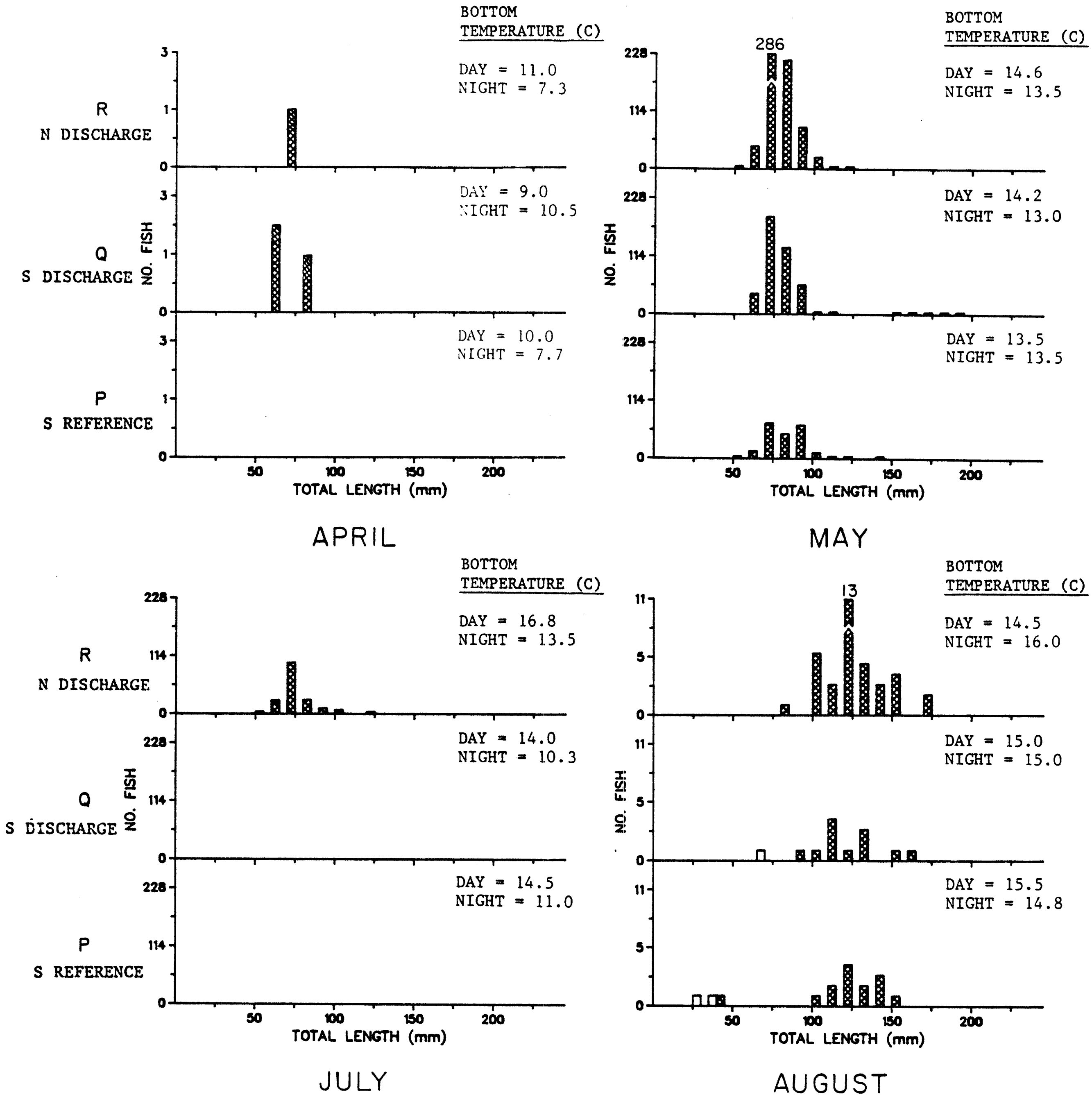
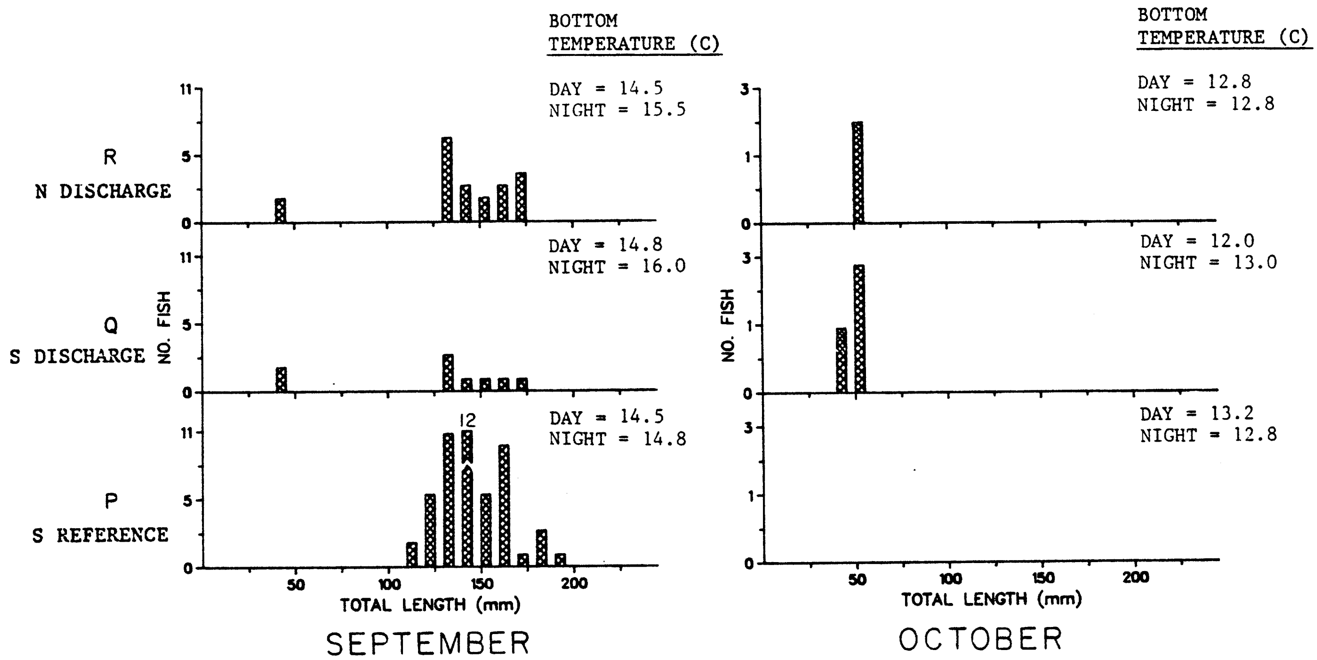


Fig. 23. Length-frequency histograms for rainbow smelt caught in duplicate seine hauls during April to November 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. □ = day ■ = night.



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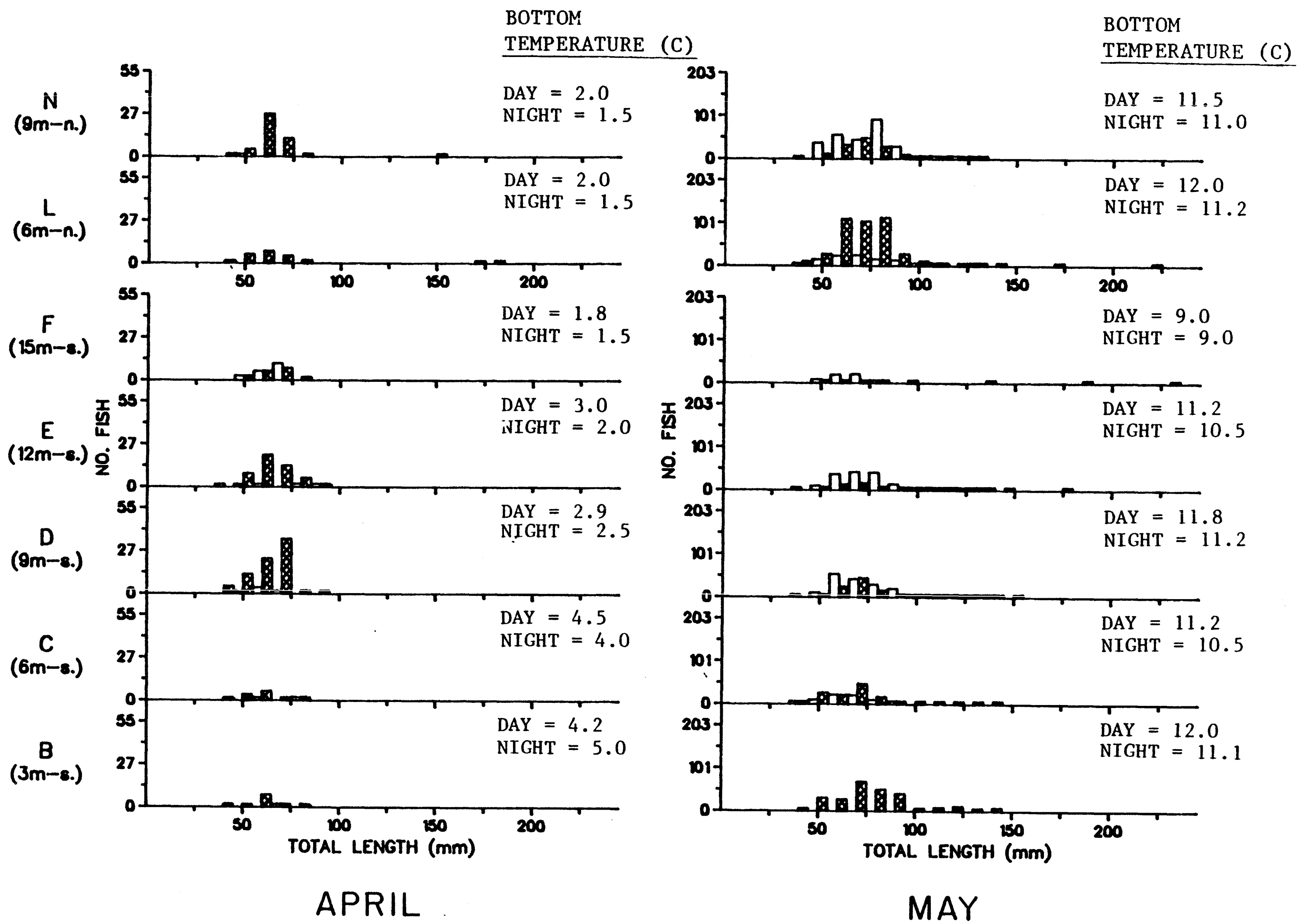


Fig. 24. Length-frequency histograms for rainbow smelt caught in duplicate trawl hauls during April to December 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. ☐ = day ■ = night * = no day sampling performed.

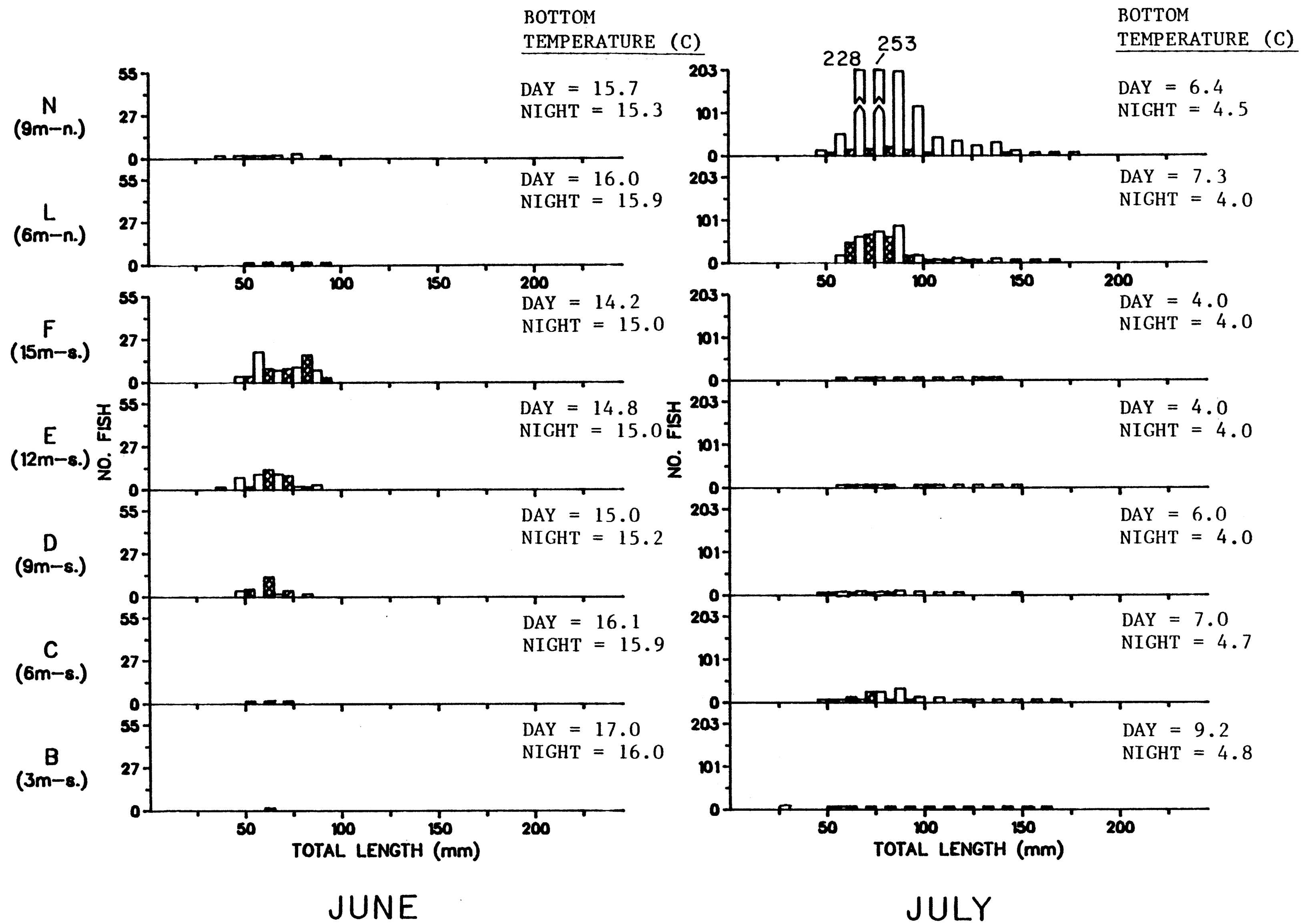
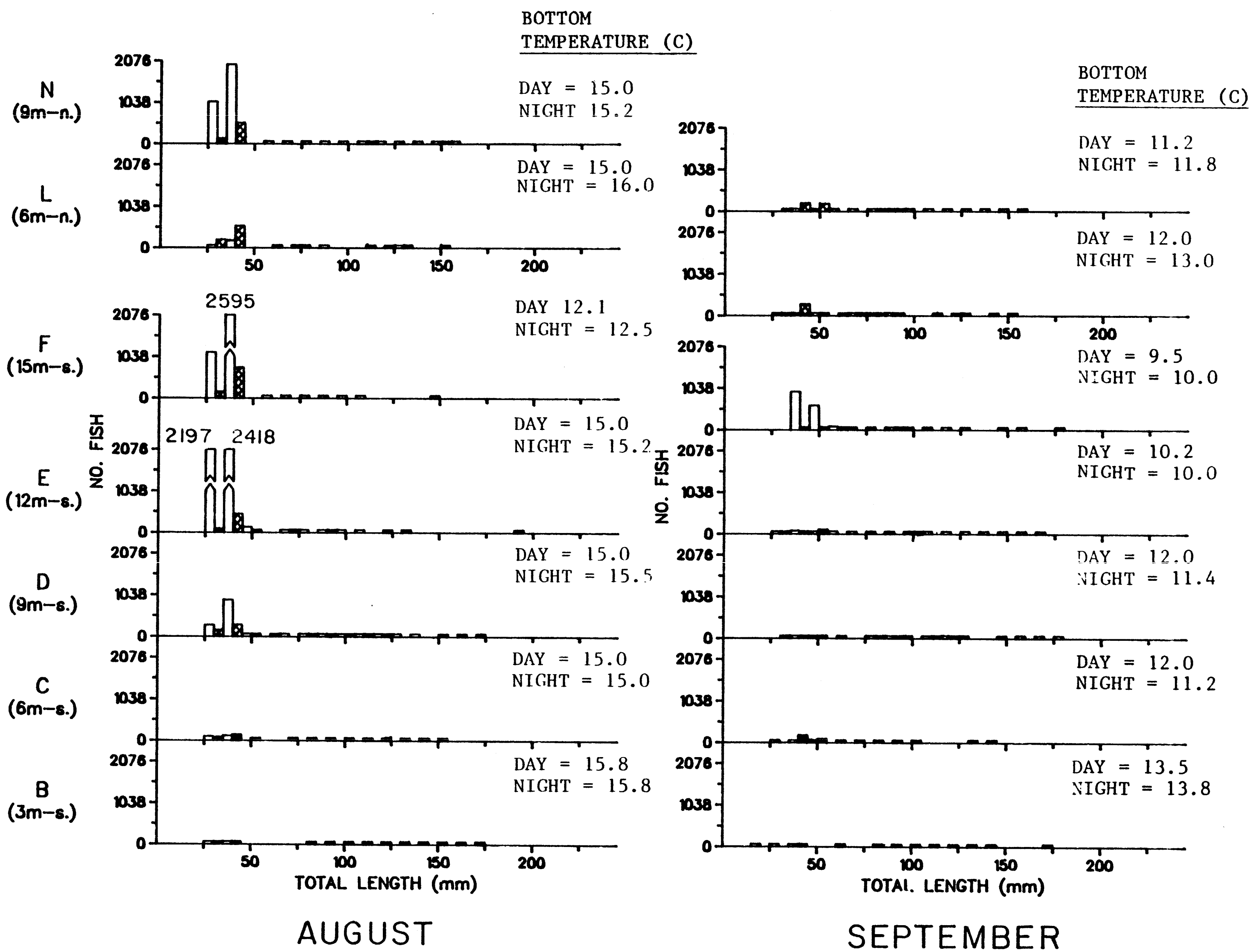


Fig. 24. Continued.



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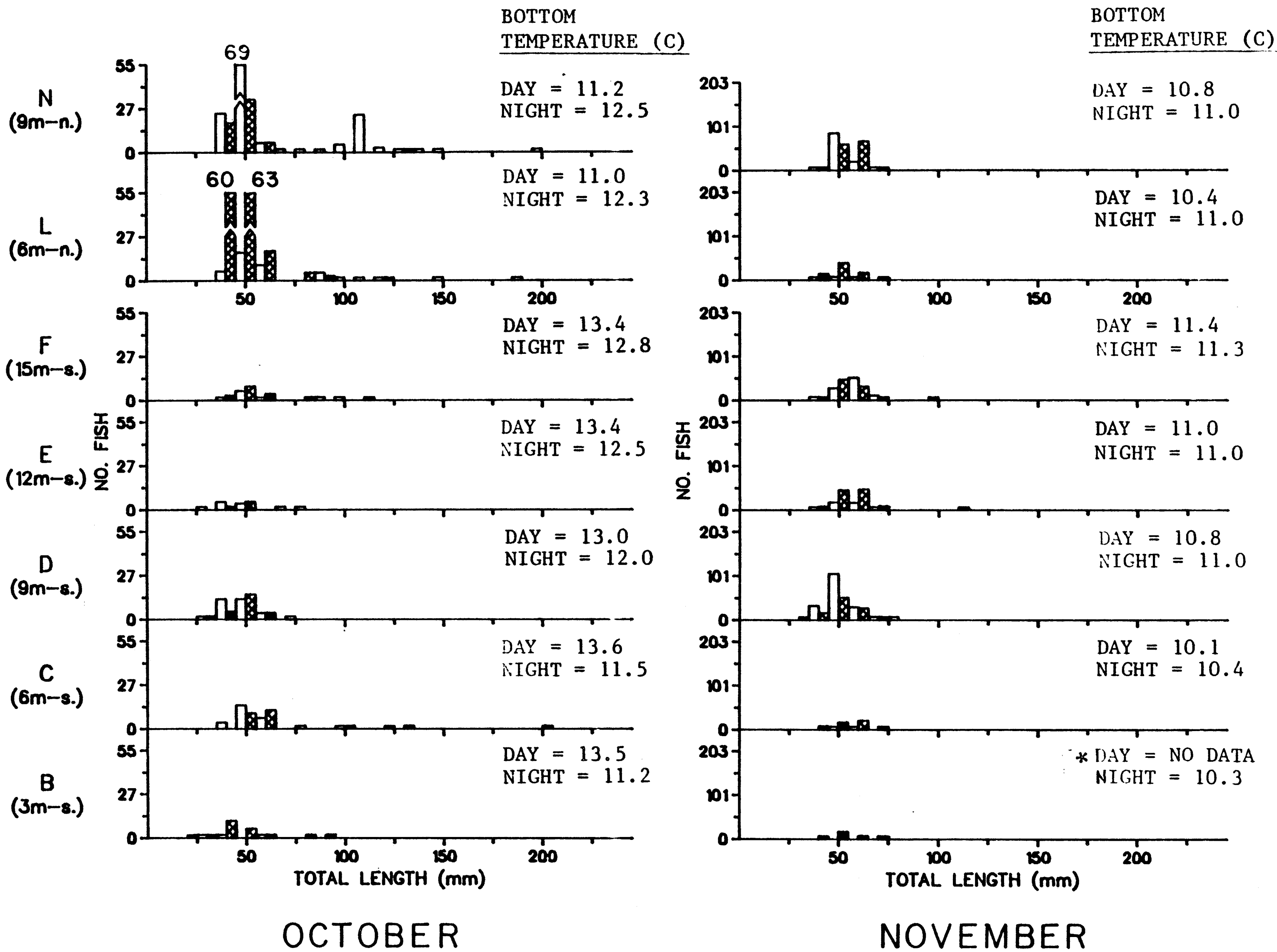

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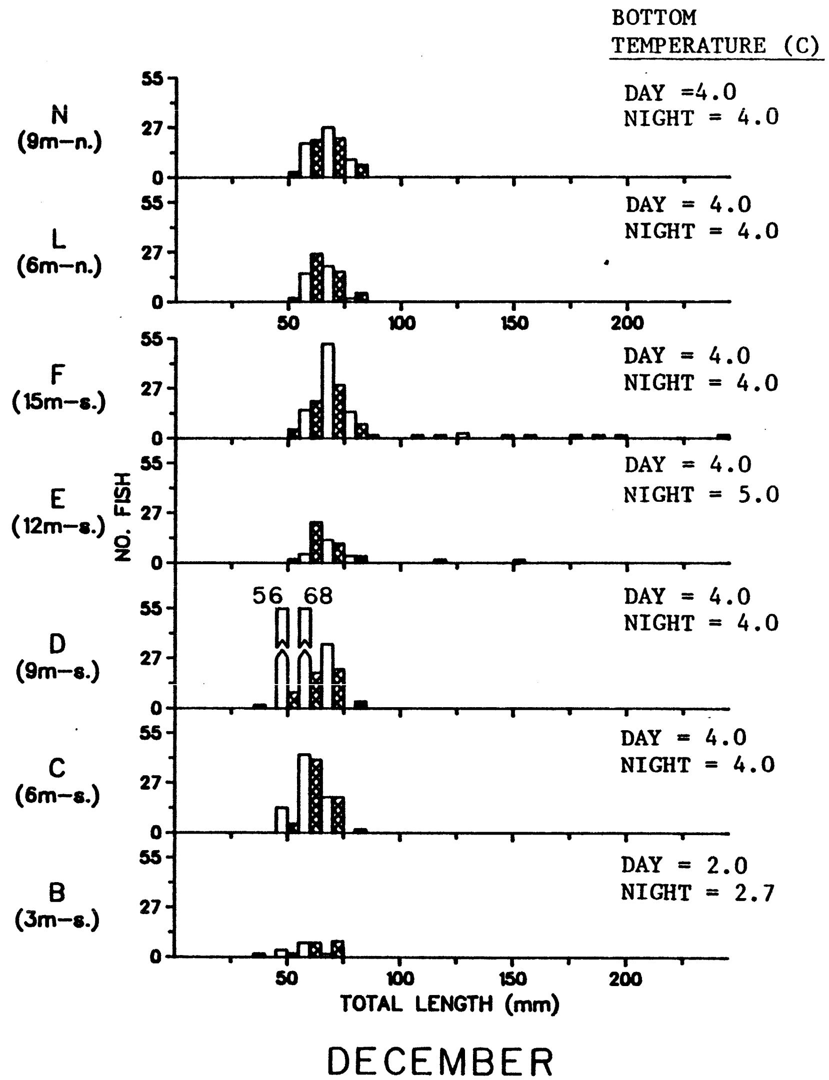


Fig. 24. Continued.

than the 7.5 C temperature observed at beach station R (north discharge) and beach station P (south reference). There was, however, only a slight difference in yearling distribution in the beach zone. Three yearlings were caught at station Q. Only one yearling was caught at station R and none at station P. No effect of warm-water discharge on yearling smelt distribution was observed at deeper stations during April. Comparable numbers of yearlings occurred at stations L (6 m, north) and C (6 m, south) (Fig. 24). Slightly higher numbers of yearlings were caught at station D (9 m, south) than at station N (9 m, north). More yearlings were collected during April 1978 (643) than during April 1979 (293). This difference in yearling catches will be discussed at the end of this section.

May--More adult smelt (120 mm and larger) were caught during May (144) than during April (12). Trawl catches (88) made up the major portion of these adult catches; the remainder was comprised of bottom gill net, seine and surface gill net catches (Figs. 25, 26). More adults were caught during May 1978 (341) than in May 1979. Occurrence of spent and ripe-running adults in May 1979 (Table 22) indicated that spawning was taking place during the May sampling period (15-18 May). Peak catches of newly hatched smelt larvae occurred in Lake Michigan and in entrainment samples during 16-19 May (see FISH LARVAE AND FISH EGGS - Rainbow smelt) suggesting that most smelt spawned during 18 April and 16 May 1979. Spawning activity during 15-18 May 1979, as indicated by the number of adults with ripe-running or spent gonads, appeared to be less intense than during 18-22 May 1978.

Diel inshore-offshore movements of smelt reported by Jude et al. (1979a) were also observed in the study area during 1979. During May 1979, adult rainbow smelt were found in small numbers at night from the beach zone to 15 m. During the day, adults were caught only in water 6-15 m (Figs. 21, 24). Since smelt spawning takes place in shallow water at night (Rupp 1959; Van Oosten 1940), nocturnal migration of adults to the beach zone and shallow areas may be related to spawning. Our 1978 data suggested that spawning may also take place in water 6 m and deeper.

Rainbow smelt move offshore after spawning. In southeastern Lake Michigan, Wells (1968) caught adult smelt between the 6- and 18-m contours during early May and at 36 m by the end of May. Low catches of adults in our study area during May probably resulted from offshore migration of the bulk of adult smelt populations.

Nine adults were caught at beach station R (north discharge), two at beach station P (south reference) and one at beach station Q (south discharge). Presence of the onshore thermal discharge may have influenced this distribution of adult smelt. Water temperatures taken while seining at these beach stations were, however, approximately the same (Appendix 2, Fig. 23). During May 1978, more adults were caught at station Q than at station R. This switch of abundance of smelt between the two stations in spring 1978 compared with 1979 may be due to the change in direction of the thermal plume. Comparable numbers of adult smelt were obtained from bottom gill nets set at station L (6 m, north) and at station C (6 m, south). Slightly higher adult catches were observed at station D (9 m, south) than at

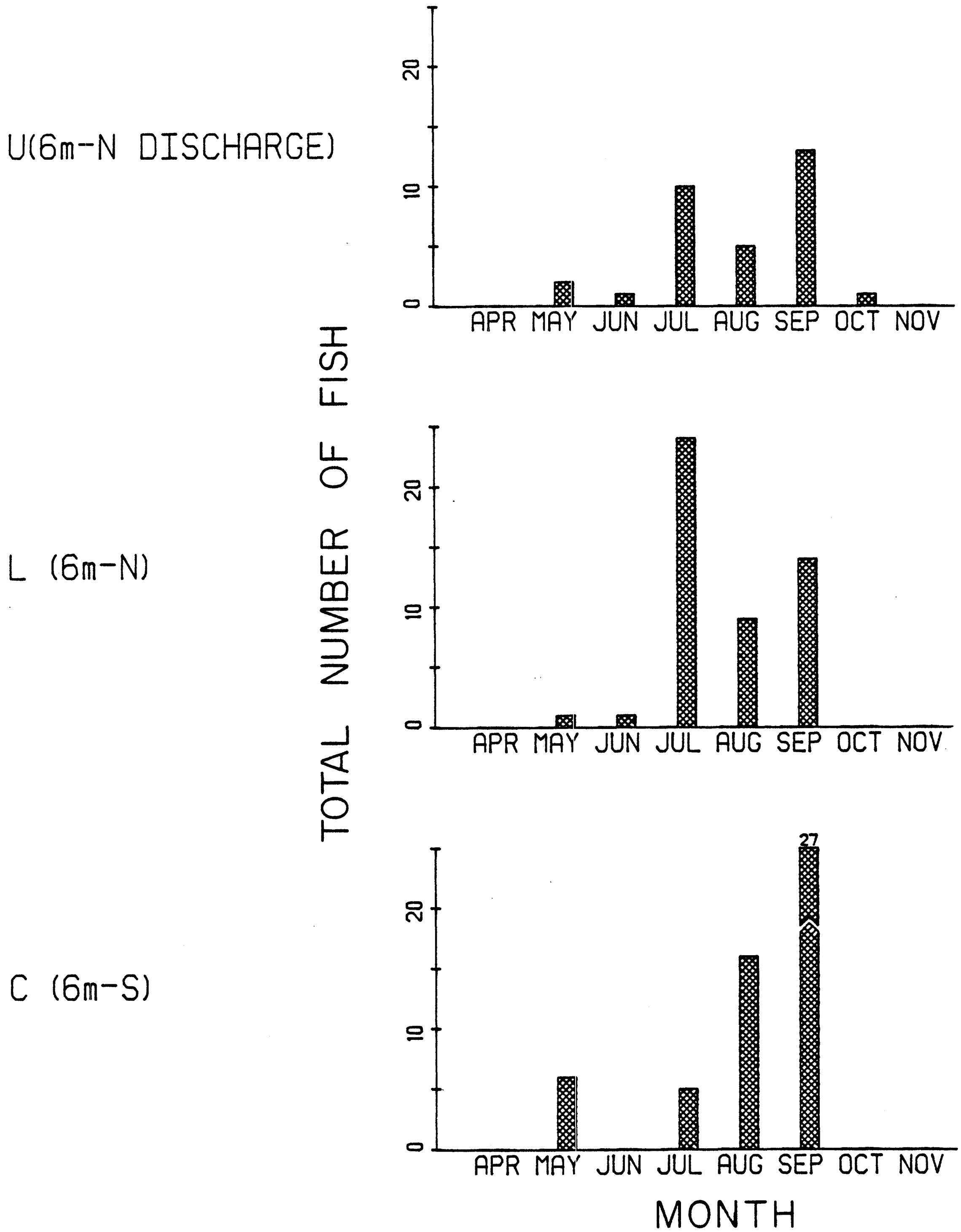


Fig. 25. Total number of rainbow smelt caught in duplicate surface gill nets fished during day and night once per month April to November 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan.
□ = day ■ = night.

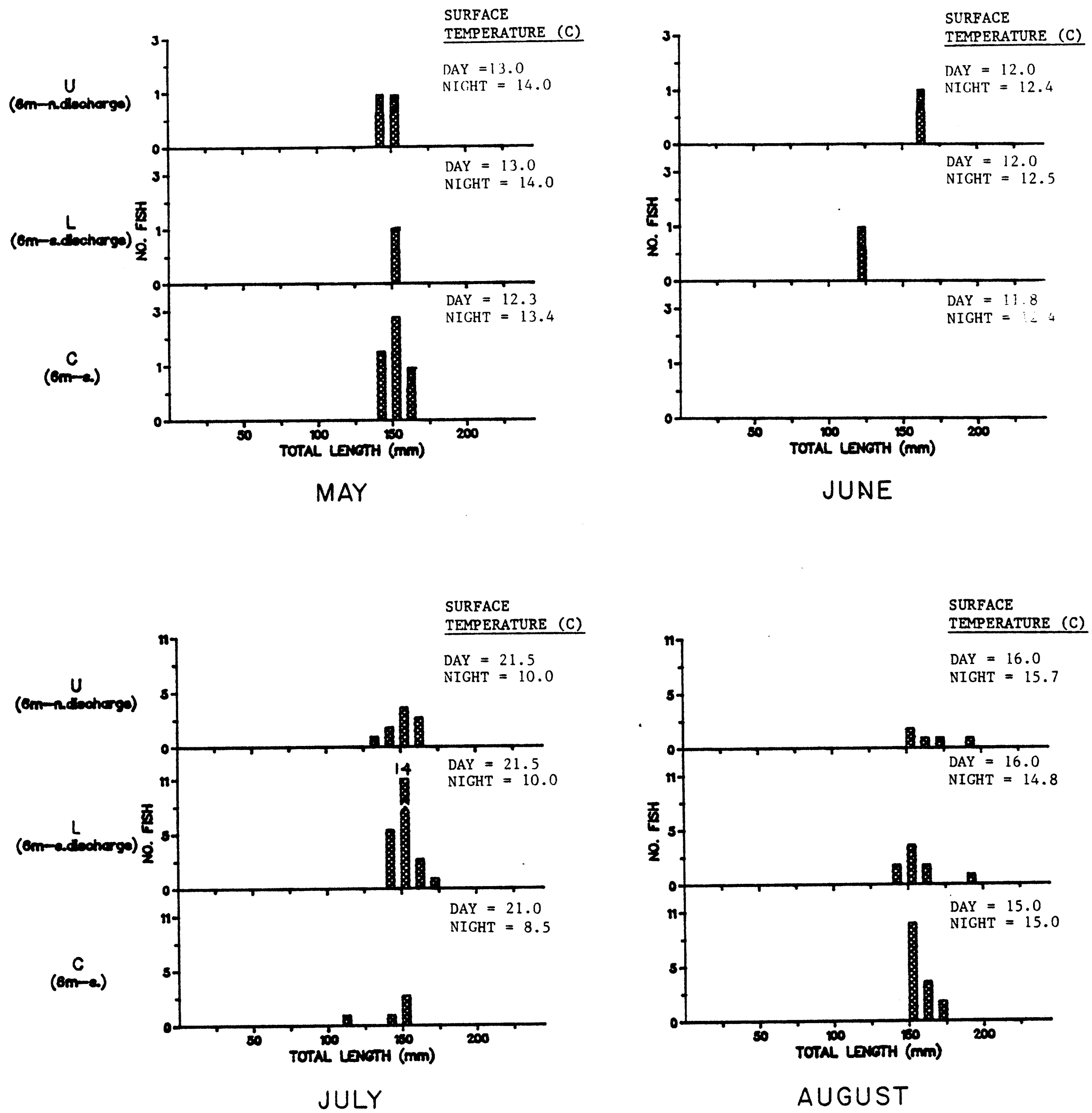


Fig. 26. Length-frequency histograms for rainbow smelt caught in duplicate surface gill nets during April to November 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. □= day ■= night.

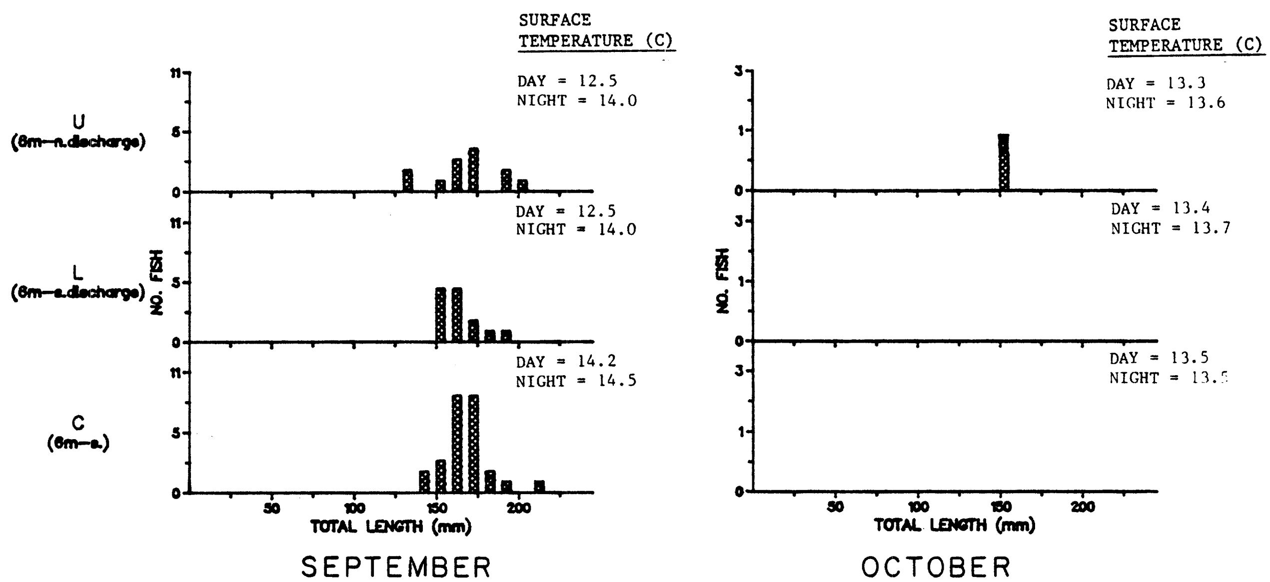


Fig. 26. Continued.

station N (9 m, north). Surface gill nets captured adult smelt only at night during May and the rest of the 1979 sampling period (Fig. 26). This predominance of night catches of adult smelt in surface gill nets, also observed in 1977 and 1978, agreed with Ferguson (1965) who reported adult smelt dispersed in the epilimnion and near surface after dark.

Yearlings 60-110 mm moved inshore in increasing numbers as water temperature continued to rise during spring. Catches of yearlings peaked in May with approximately 3168 specimens collected. At night, yearlings were most abundant in the beach zone (Fig. 23); catches generally declined toward deeper water (Fig. 24). During the day, yearlings were caught only from 6 to 15 m with highest concentrations at 9 m. Similar diel inshore-offshore migrations of yearlings were also documented during 1978. Net avoidance during the day may also influence day catches in shallow waters. Combined night seine catches at the three Lake Michigan beach stations accounted for 1309 of the 3168 yearlings collected in 1979. Appreciable numbers of yearlings were also caught in night seine hauls during May 1978. Substantially smaller numbers of yearlings were caught in the beach zone during remaining months (June-November) in 1979 (Fig. 23), a pattern observed in 1977-1978. These data suggested that yearlings utilized the beach zone only briefly during the year.

Yearlings appeared to be more abundant near the north than the south transect. More yearlings were caught at beach station R (663), than at beach stations Q (429) and P (219). Yearlings were also abundant on the north transect at deeper stations. Catches at 6 and 9 m (respectively 511 and 408) were substantially higher than those made at corresponding depths (202 at 6 m and 277 at 9 m) on the south transect (Fig. 20). These catch differences may be due to discharge of heated water at the north transect. Water temperatures at the beach, 6- and 9-m stations on the south transect were, however, approximately the same as those observed at corresponding stations on the north transect (Appendix 3). As has been observed with adult data, the catch difference between beach stations Q and R may also be influenced by discharge of heated water.

As was found in April, more yearlings were caught at night than during the day in May. This difference in diel catches may be due to inshore movement of yearlings combined with daytime net avoidance. Despite a large influx of yearlings to the inshore area, catches of this size group were much lower in May 1979 than in May 1978. As will be discussed later in this section, the 1979 yearlings probably originated from a weak year class in 1978.

June--Adult smelt were relatively scarce in June. Only seven adult smelt were collected, of which four were caught at 12 m and three at 6 m. During June, adult smelt were caught only in surface and bottom gill nets (Figs. 26, 21). No adults occurred in trawls or seines. Low catches of adults were also observed during June 1977 and 1978. Water temperatures at time of gill net setting in June were 8.5-12 C in 1977, 9.8-18.5 C in 1978 and 7.5-13.9 C in 1979. These data indicated that adult smelt rarely return to inshore water in June despite availability of relatively cool water.

In 1978 smelt spawning in the study area continued through early June. Occurrence of a spent male in June samples (Table 22) and of newly hatched larvae during 27-29 June and 2-3 July (see FISH LARVAE AND FISH EGGS-Rainbow Smelt) suggested that some spawning took place during early June and mid-June 1979.

Catches of yearlings in June (204) declined drastically from the peak of 3168 observed in May. During June, yearlings were caught only in trawls and mostly at deeper stations. They were found from 6 to 15 m during the day and from 3 to 15 m at night (Fig. 24). Highest concentrations occurred at 15 m both at night and during the day. Most yearlings probably moved to deeper water because of increased water temperatures inshore. Water temperatures taken during trawling ranged from 14 to 17.4 C. Decrease of yearling catches in June 1978 also resulted from increased water temperatures (Jude et al. 1979a). Departure of yearlings to deeper water at the approach of a warming trend was also observed in southeastern Lake Michigan (Jude et al. 1979b). During June 1977, yearling catches were relatively high because of cool inshore water (4.5-11.7 C). Fewer yearlings were caught at station C (6 m, south) than at station L (6 m, north). Catches at station D (9 m, south) were, however, slightly higher than those at station N (9 m, north) (Fig. 24).

July--Adult smelt probably returned to the study area during 19-22 July due to an upwelling of cold water (Appendixes 1, 2 and 3). Larger numbers of adults were caught during July (184) than during June (7). They were collected in small numbers from 3 to 15 m at night (Fig. 24). A few adults were also caught in night seines and surface gill nets. Adult smelt were caught in appreciable numbers in day trawls from 6 to 12 m with highest catches taken at 9 m. During July, no adults were caught in bottom gill nets which are normally the most effective gear for sampling adult smelt. Reasons for absence of adults from July bottom gill nets are not known.

Yearlings became more common in the inshore area during July than in June as a result of the upwelling. The yearling populations inhabiting the study area during July, as indicated by our catches, did not reach levels we observed during May. Approximately 1871 yearlings were collected during July. Yearlings occurred from 3 to 15 m both at night and during the day. They were most abundant at 6 and 9 m on the north transect. An appreciable number of yearlings were also caught in night seines at beach station R (north discharge), but none were found at beach station Q (south discharge) or beach station P (south reference). Yearlings probably preferred the relatively warm water (13.5 C) at station R to the 4.5 C water at stations Q and P.

More adults and yearlings were caught on the north transect than on the south transect during July. Catches of adults and yearlings at station L (6 m, north) were respectively 55 and 466. At station C (6 m, south) only 29 adults and 144 yearlings were collected (Fig. 24). A large difference in catches was also observed at the 9-m contour where 112 adults and 1036 yearlings were caught at station N (9 m, north) as compared to 3 adults and 52 yearlings collected at station D (9 m, south). Water temperatures varied only slightly between stations C and L and stations N and D (Appendix 3, Fig. 24).

The heated discharge water which caused a substantial increase in water temperature at beach station R (north discharge) may in part have influenced the distribution of yearlings at 6 and 9 m.

Unlike the patterns observed during April and May, in July more yearlings were caught during the day than at night. Water temperatures, again, appeared to be an important factor determining this diel distribution of yearlings. Yearlings may have temporarily avoided the study area at night because of low temperatures (4.0-4.8 C); day temperatures were 4.0-9.2 C.

During July YOY smelt were generally still too small to be retained by our trawls. Only one YOY (30 mm) was caught in July 1978, and one YOY of approximately the same size was caught in July 1979. During 1977, however, probably because there were more early spawners, 341 YOY were collected in July trawls.

August--Adult smelt were usually found in deep water during summer (Ferguson 1965; MacCallum and Regier 1970). A small number of adults (63) was collected during August 1978. Approximately 260 adults were caught during August 1979. A mild upwelling which cooled inshore water to 12.1-16 C during August had probably attracted some adult smelt back to the study area. Adults were caught in all types of gear during August. They occurred at all stations at night and from 1.5 to 12 m during the day (Figs. 21, 22, 23, 26). Adults were most abundant at 9 m both at night and during the day (Fig. 21).

As was found in July, more adults were seined at beach station R (north discharge) than beach station Q (south discharge) or beach station P (south reference) (Fig. 25). No temperature difference between these stations was observed during our August sampling. Causes of higher catch at station R than at the other beach stations were not clear. More adults were caught at station C (6 m, south) than at station L (6 m, north), but less were found at station D (9 m, south) than at N (9 m, north) (Figs. 20, 24).

Yearling catches declined substantially in August from the levels we observed during July. Yearlings in small numbers were collected from the beach zone to 15 m at night. During the day, they were confined to the 12- and 15-m contours. Most yearlings probably remained in deeper water, but smelt of this size group may also inhabit the mid-water area. In Lake Erie, MacCallum and Regier (1970) found yearling populations in the thermocline during summer.

During August, YOY smelt 30-50 mm were caught in trawls from 3 to 15 m both during the day and at night (Fig. 24). Highest concentrations of YOY occurred at 15 m at night and 12 m during the day. YOY usually frequented the deeper part of the study area in August during 1977-1979. Jude et al. (1979a) and MacCallum and Regier (1970) indicated that YOY progressively moved offshore as they grew older. High catches of YOY at 15 m during 1978 and 1979 suggested that these young smelt also ranged into water deeper than 15 m. Day trawling at 18 and 21 m conducted during August 1977 however, yielded only low

catches of YOY (Jude et al. 1978). YOY in small numbers inhabited the beach zone during the summer. A few YOY were caught in seines during August 1978 and 1979 (Fig. 23), but none were collected in 1977.

As has been observed in 1977 and 1978, catches of YOY peaked in August during 1979. During the period 1977-1979, YOY reached the same modal length (40 mm) in August. These data suggested that, although there may be some delay or acceleration of the warming of inshore water during spring, the period of peak spawning of rainbow smelt in the study area probably varied very little during these 3 yr.

More YOY were caught at station L (6 m, north) and station N (9 m, north) on the north transect than at the reference stations of corresponding depths (Fig. 24). No difference in water temperatures between the north and south transects was observed during the sampling trip. Causes of these catch differences could not be determined. Contrary to August 1978 results, more YOY were caught during the day than at night during August 1979. Catches of YOY in August 1979 (16,876) increased dramatically over their level in August 1978 (5126). This increase resulted from a stronger 1979 year class and will be discussed at the end of this section.

September--Peak catches of adult smelt occurred in September. An upwelling which lowered inshore water temperatures to 11.5-15.0 C during 19-21 September probably caused adults to move to shallow areas. As occurred in August, adult smelt were caught in all gear types during September. Bottom gill nets were the most productive gear accounting for approximately 52% (275 of 523) of the adult smelt collected. Appreciable numbers were caught in seines, surface gill nets and trawls (Figs. 23, 24, 25).

During September, most adult smelt were caught close to shore. At night, they were distributed from the beach zone to 12 m, with most being found at 1.5 m. Day catches of adults were made from 1.5 to 15 m, with the peak occurring at 3 and 6 m (Figs. 21, 24).

Adults in September were more common at the south transect beach zone than at the north transect beach zone. Forty-four, 19 and 9 adult smelt were caught at beach station P (south reference), beach station R (north discharge) and beach station Q (south discharge) respectively. Lower water temperature was found at station P (14.0 C) than at station Q (15 C) or station R (15.5 C). Trawls captured 12 adults at station D (9 m, south) and 33 at station N (9 m, north) (Fig. 24). More adults were, however, caught in bottom gill nets, surface gill nets and trawls at south transect 6-m station C (52) than at north transect 6-m station L (17).

Yearling catches were slightly higher in September than in August. Yearlings were found from 3 to 12 m at night, but were restricted to deeper water (6-15 m) during the day. A small number of yearlings were also caught in night seines at station P (south reference). As has been mentioned in the discussion of August data, low catches of yearlings in September may be due to

the migration of smelt in this size group to deeper water. More yearlings were caught at station L (6 m, north) and station N (9 m, north) than at station C (6 m, south) and station D (9 m, south).

During September, YOY were collected in smaller numbers than during August. Similar decline of YOY catches in September also occurred in 1977 and 1978. YOY were reported to move offshore during fall. In Lake Erie, MacCallum and Regier (1970) caught YOY with yearlings and adults in water 24-27 m in September. Decline of YOY in September catches during 1977-1979 suggested that YOY that inhabited the study area during August also moved offshore during September. YOY were trawled from 3 to 15 m both at night and during the day (Fig. 24). Low numbers of YOY were also found in night seines at station Q (south discharge) and station R (north discharge) (Fig. 23). As was found in August, YOY tended to remain in deep water in September. Highest catches occurred at 15 m during the day and at 6 and 9 m at night (Fig. 24).

More YOY and yearlings were caught at station L (6 m, north) than at reference station C (6 m, south). Catches of these two size groups at station N (9 m, north) were also higher than those at station D (9 m, south) (Fig. 24). Water temperatures at stations C (11.2-12.0 C) and D (11.4-12.0 C) differed only slightly from those at stations L (12-13 C) and N (11.2-11.8).

October, November and December--Yearlings and adults were scarce inshore during fall 1977-1979. In Lake Erie, Ferguson (1965) reported catching adults and yearlings at 36 m during October. In our study area, a few adults were found from 3 to 9 m during October 1979. Yearlings occurred in small numbers from 3 to 15 m (Fig. 24). As has been observed in September, more adults and yearlings were caught at north transect stations L (6 m, north) and N (9 m, north) than at south reference stations C (6 m, south) and D (9 m, south) (Figs. 21, 24). Low numbers of yearlings were caught during November and December, all in deep water (12-15 m). No adults were caught in November. A few adults were collected at 12-15 m in December.

Most YOY, like adults and yearlings, probably inhabited deeper water during fall. In southeastern Lake Michigan, Wells (1968) caught YOY smelt in water 18-36 m during October. YOY catches in October dropped sharply from the level observed in September (Fig. 24). Trawl catches during October, November and December however, revealed that a substantial population of YOY remained in the study area throughout fall. Similar residence of YOY in inshore water was observed during fall 1977 and 1978. During October and December, YOY were trawled in water 3 to 15 m both at night and during the day. Highest concentrations of YOY during this period were observed at 6 and 9 m. A few YOY smelt were also caught in night seines in October and November.

During October YOY were more common at plant-influenced station L (6 m, north) and station N (9 m, north) than at reference stations of corresponding depths (C and D). During December abundance of YOY appeared to be reversed. More were caught at reference stations C (6 m, south) and D (9 m, south) than at station L and N. In November, catches at reference stations (C and D) were approximately the same as those at stations L and N.

Seasonal distribution - Pigeon Lake--Rainbow smelt are not residents of Pigeon Lake. No major smelt run was observed in Pigeon Lake or Pigeon River, but a few smelt may utilize this tributary water as a spawning ground. During May 1978, a few smelt with ripe-running gonads were collected in Pigeon Lake and impinged at the Campbell Plant. A few smelt larvae were also caught at beach station V (undisturbed Pigeon Lake) and station X (undisturbed Pigeon Lake) in 1979. No ripe-running smelt were however, caught in Pigeon Lake during April and May 1979.

Adult and yearling smelt were scarce in Pigeon Lake during 1977-1979. YOY may, however, enter this tributary water in large numbers (see YEARLY ENTRAINMENT SUMMARY). Consumers Power Company (1975) found appreciable numbers of adult smelt (496), mostly in spring, in weekly impingement samples collected during January 1974-March 1975, suggesting that more adult smelt entered Pigeon Lake during that year. In 1979 we caught smelt in Pigeon Lake only during May, August and October. Smelt catches in Pigeon Lake during May contained three yearlings 51, 61 and 65 mm, which were collected in night seines at beach station S (influenced by Lake Michigan) when water temperature was 12.6 C. A 61-mm yearling was also caught during May at beach station V (undisturbed Pigeon Lake) when water temperature was 14.9 C.

During August, five YOY smelt 25-29 mm were caught in day seines at station S; water temperature was 15.5 C. In October five YOY (47-61 mm) occurred in night seines at station S. Day seines at station S also captured a 50-mm YOY during October. Since smelt larvae were scarce in Pigeon Lake during 1978 and 1979, yearlings and YOY smelt collected in 1979 probably migrated from Lake Michigan into Pigeon Lake.

Temperature-catch relationships--Rainbow smelt is a cold-water species. In Lake Erie adult smelt were reported to prefer a temperature of 6 C (Ferguson 1965). Jude et al. (1979b) caught most adult smelt in water temperatures of 6-8 C. In the study area, adult smelt were caught mostly in water temperatures of 10-16 C during 1979. Most yearlings occurred in mean water temperatures of 6-14 C. Adults and yearlings were found in slightly cooler temperatures in 1977 and 1978. During 1977-1978 most yearlings were collected in mean water temperatures of 6-12 C and most adults in mean water temperatures of 6-14 C.

Water temperatures appeared to be an important factor determining the distribution of adult and yearling smelt in the inshore area. As has been discussed in the previous section (Seasonal Distribution), increase in catches of adults and yearlings in July was due to the return of yearlings to the study area during an upwelling of cold water. Similarly, increased smelt catches associated with cooling of inshore water have been frequently observed in 1977 and 1978. Thermal preference of rainbow smelt, however, may vary considerably. During July 1977 and June 1978, despite low temperatures in the inshore area (6-14.9 C and 8.5-14.8 C, respectively), relatively small numbers of adults and yearlings were collected. In Lake Erie, MacCallum and Regier (1970) reported catching large quantities of yearlings in water 12-18 C, when cooler water was available only a few kilometers away.

As was found in 1977-1978, YOY occurred in slightly warmer water than adults and yearlings (Fig 27). YOY were caught in water temperatures from 9.5 to 17.0 C. Unlike the adult and yearling distribution, YOY appeared to be little affected by change of water temperature in the inshore area. Peak catches of YOY occurred in the water temperature range of 9.0-19.5 C during August 1977, 8.0-24.0 C in August 1978 and 12.1-16.0 C in August 1979.

Impingement--Although rainbow smelt is an abundant species in Lake Michigan, relatively few smelt were found on the traveling screens of the plant. During 1978, the projected number of rainbow smelt impinged was 1333. Total number of smelt impinged in 1979 was estimated at 2513, of which 2113 were YOY (30-60 mm), 203 were yearlings (50-100 mm) and 197 were adults (120-180 mm).

During January 1979 only a few yearlings were impinged by the plant. No smelt were impinged during February and March. These data suggested that very few smelt inhabited the inshore water during winter. Approximately 21 adults and 20 yearlings were estimated impinged during April and May. Rainbow smelt move to shallow areas or into tributary streams to spawn during these 2 mo, but very few have been caught in Pigeon Lake. Low impingement of smelt in April and May agreed with observations on scarcity of smelt spawning in Pigeon Lake or Pigeon River. Adult smelt collected showed well developed gonads. A few ripe-running adult smelt were also collected in 1978 during the same period. Impingement of rainbow smelt remained low during June and July 1979. Only 14 adults and 21 yearlings were impinged.

Smelt impingement increased sharply during August-December due to the abundance of YOY in the inshore area. YOY 30-50 mm comprised the bulk of impinged smelt during this period. Similar to YOY field catches, YOY impingement peaked in August, with an estimated 740 impinged. YOY were caught in Pigeon Lake only during August and October. Impingement data, however, revealed that YOY entered Pigeon Lake every month during summer and fall (Appendix 8). Estimated number of YOY impinged declined to 230 in September and increased to 468 in October and 524 in November (Appendix 9). Lower numbers of YOY were estimated impinged in December.

Adults (162) and yearlings (135) were collected in low numbers from the traveling screens during August-December. Adults occurred in impingement samples every month during August-December; yearlings were found only in August and September (Appendix 8).

Estimated number of smelt impinged during 1979 (2513) nearly doubled that of 1978 (1333). The total number of adults and yearlings impinged in 1979 (400) substantially declined from the 858 individuals impinged in 1978. Impingement of YOY (2113) increased appreciably from its 1978 level (475).

Plant impacts--As was found in 1978, the total number of juvenile and adult smelt impinged during 1979 (2513) was relatively low compared to commercial and sport catches in Lake Michigan. Approximately 1.5 million smelt larvae and fry were entrained during 1978 and 3.6 million during 1979. This increase in entrainment was probably due to the higher abundance of smelt

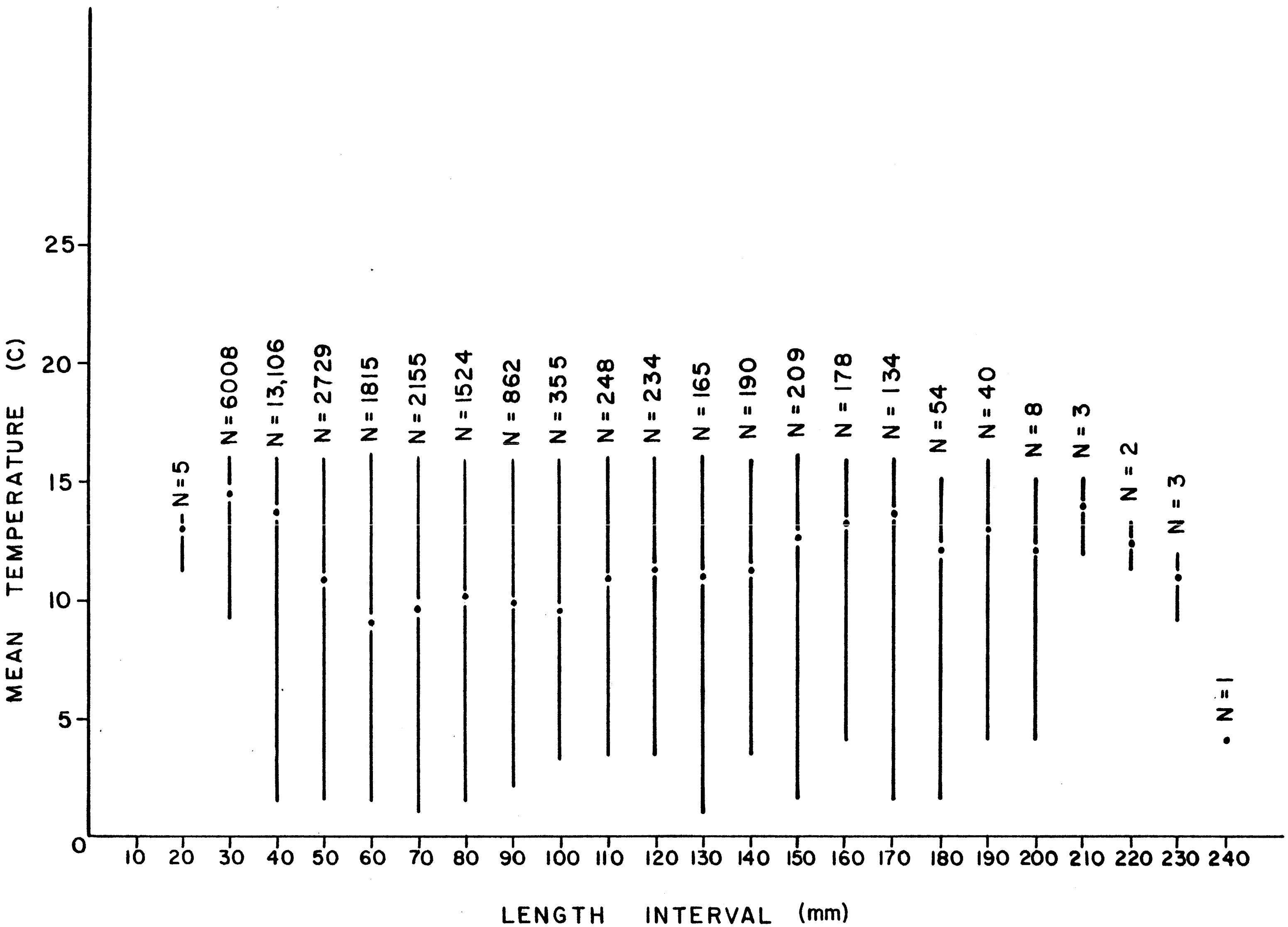


Fig. 27. Weighted-mean temperatures at which various sizes (10-mm length groups) of rainbow smelt were collected by all gear types from Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan, 1979. Vertical bars represent the range, N = number of fish.

larvae and fry in 1979 than 1978. Impingement and entrainment losses probably did not cause any declines in smelt populations during 1977-1979. Results of field sampling suggested that smelt populations were on the increase in Lake Michigan near the Campbell Plant during this period.

Other considerations--The number of YOY smelt collected in trawls and seines in the study area in 1977 was 11,131, in 1978 it was 9838 and 1979 it was 22,770. Average YOY catch-per-trawl-haul (catch-per-unit-effort) was 318 in 1977, 91 in 1978 and 429 in 1979. These data suggested that rainbow smelt tended to have a strong year class every other year, with 1977 and 1979 being strong year classes. Alternation of year class strength of rainbow smelt also occurred in Lake Erie where Ferguson (1965) found that YOY were abundant only during even calendar years.

Yearling catches in 1978 (14,368) and in 1979 (6271) with respective catch-per-unit-efforts of 624 and 25, also reflected the alternation of year class strength of rainbow smelt. The great abundance of yearlings observed during 1978 resulted from the strong 1977 year class, while the weak 1978 year class yielded only low catches of yearlings in 1979. Low catches of yearlings in 1977 (1446) were due to low yearling populations during that year and to lack of samples from April and May.

Walter and Hoagman (1975) reported that year class strength of rainbow smelt in Green Bay, Lake Michigan, is positively correlated with abundance of spawning stock. Based on these findings and catches of YOY during 1977-1979, large adult populations would be present in the study area in 1977 and 1979. Because the bulk of adults occurred in the study area only for a brief period during the spawning run, their abundance could have been missed by our sampling methods. In 1979 fewer adults were caught than in 1978 probably because no major spawning run occurred during our sampling trip.

Rainbow smelt populations in the study area appeared to increase steadily during the period 1977-1979. Total numbers of rainbow smelt collected were low in 1977 (12,900), intermediate in 1978 (25,300) and highest in 1979 (30,200). As has been previously discussed, yearlings and YOY made up the bulk of the catches during the 3-yr period. Catch-per-unit-effort of YOY during 1977-1979 revealed that the strong 1979 year class was substantially more abundant than the previous strong year class (1977). This relationship was probably also true for yearlings. Jaiyen (1975) reported that an important food item of smelt, Pontoporeia, is also a major food item of alewife. Increase of smelt populations probably resulted in part from decline of alewives in the study area (see Alewife).

YOY smelt reached modal lengths of 40 mm in August, 50 mm in September and 60 mm in November. During 1977 and 1978, YOY also grew to a modal length of 60 mm in November, suggesting that YOY smelt experienced the same growth rate during the period 1977-1979.

Catch data analyzed for 1977-1979 indicated that seasonal depth distribution of YOY, yearlings and adult smelt varied only slightly from one year to the next. Substantial fluctuations of abundance of each size group,

however, were observed during 1977-1979. Throughout summer and fall YOY smelt can readily be separated from larger smelt by length modes. Size ranges of YOY smelt caught in trawls and seines during 1977-1979 were in 20-40-mm length intervals in July, 20-50 mm in October and 40-80 mm in December. Yearlings may be separated from older smelt by length modes only during April, May and June. In July and August, the distinction of yearlings from older fish by length modes becomes difficult due to considerable size overlap between the two groups. During September-December, only small numbers of yearlings and adults were collected.

Although smelt feed mostly on invertebrates, they often consume fish (Gordon 1961). O'Gorman (1974) reported that young alewives were found in 27% of the stomachs of large smelt (>143 mm) examined. In Crystal Lake, Michigan, emerald shiners made up the bulk of smelt food in summer (Creaser 1925). Rainbow smelt are also a cannibalistic species. Gordon (1961) and Van Oosten (1940) indicated that most fish found in smelt stomachs were young smelt. Preliminary examination of stomachs of adult smelt collected in the study area revealed that YOY alewife and smelt comprised the major portion of fish eaten.

Summary--Rainbow smelt was one of the most abundant species collected in Lake Michigan. In the study area, smelt spawned mostly during mid-April to mid-May. Some spawning also took place during late May and early June. Offshore movements of adult smelt started in May. Greatest adult catches occurred in July, August and September with peak catch occurring in September. Only a few adults were caught in the fall. Most adults were caught at 6 m or deeper during spring and summer, except in September when most were caught closer to shore.

Catches of yearlings peaked in May and in general declined through the summer. During the fall catches were low. Yearlings were most common at depths greater than 9 m during the spring and summer and moved offshore in August.

Catches of YOY peaked in August and began to decline in September as a result of offshore movements. A substantial population of YOY, however, remained in the study area throughout the fall. High concentrations of YOY occurred at 12 and 15 m during August and at 6, 9 and 15 m during September. Highest concentrations during the fall occurred at 6 and 9 m.

Rainbow smelt of all sizes exhibited diel horizontal migration with a movement to shallow water at night and a return to deeper water during the day. Adults were caught mostly in water temperatures of 10 to 16 C and yearlings were caught mostly in water temperatures of 6 to 14 C. YOY 50 mm and less occurred in warmer water than larger smelt.

Low numbers of adults and yearlings were impinged during 1979. YOY 26-60 mm were drawn into the plant at a relatively high rate, but most passed through the traveling screens and appeared in entrainment samples.

Spottail Shiner--

Introduction--Catches of spottail shiners in Lake Michigan decreased to 9474 in 1979 from 12,764 in 1978 despite little change in sampling effort. In Pigeon Lake the reverse was observed; catches increased to 3194 fish in 1979 from 2456 in 1978. Spottails were the third-most abundant fish collected in Lake Michigan and Pigeon Lake comprising 12 and 17% of the standard series catch, respectively.

Seasonal distribution--As is typical of their seasonal distribution in southeastern Lake Michigan, spottail shiners were nearly absent from the nearshore water during April. Wells (1968) found that spottails overwinter in water between 18 and 27 m in southeastern Lake Michigan. Jude et al. (1979b) stated that spottails migrated shoreward beginning in March and completed their migration by May. Only 31 fish were caught during April 1979. Most were 75-125 mm (Figs. 28 and 29). Twenty-six were caught during April 1978.

Few spottails were seined in Pigeon Lake during April; all (20) were caught at Lake Michigan influenced beach station S. In 1978, 28 spottails were collected in Pigeon Lake during April.

May--A dramatic increase in spottail catch occurred from April to May in Lake Michigan; 1313 were caught during May. These fish were mostly adults (85-135 mm). Jude et al. (1979a) reported the size range of most adult spottails caught in March and April was 105-134 mm. Peer (1966) found that sexual maturity seems to occur only after a total length of approximately 68 mm is reached. Beach seines (Fig. 29) accounted for 171 fish, bottom trawls caught 744 (Fig. 30), 397 occurred in bottom gill nets (Fig. 28) and 1 was caught in a surface gill net (Fig. 31). Densities of spottail shiners were highest in the beach zone out to 6 m since 76% of the catch was collected from this depth interval. A similar pattern was exhibited in the vicinity of the Campbell Plant during May 1978 when over 50% of the fish were caught in 6 m of water or less. Presence of six fish with spent gonads (Table 23) suggested some spawning occurred during May.

Pigeon Lake catches of spottail shiners in May (358) increased considerably over April levels (20) (Fig. 32). In May all but 32 of the Pigeon Lake spottail catch was taken at station S (Lake Michigan influenced). The presence of small newly hatched larvae at station S (influenced by Lake Michigan) indicates that spawning took place during May in Pigeon Lake (see FISH LARVAE AND FISH EGGS-Spottail Shiner). During our 1977 and 1978 studies (Jude et al. 1978, 1979a) beach station S was documented as the preferred habitat as well as a nursery area for spottail shiners in Pigeon Lake. Yager (1976) reported that spottail shiners prefer a bottom of sand or gravel. In northern Lake Michigan Basch (1968) caught fewer spottails in areas where there were dense beds of submergent vegetation. In our study, relatively few were caught at undisturbed Pigeon Lake station V which has a bottom of soft peat and is densely covered with aquatic macrophytes. Station S is characterized by a fine sand bottom and a steep slope.

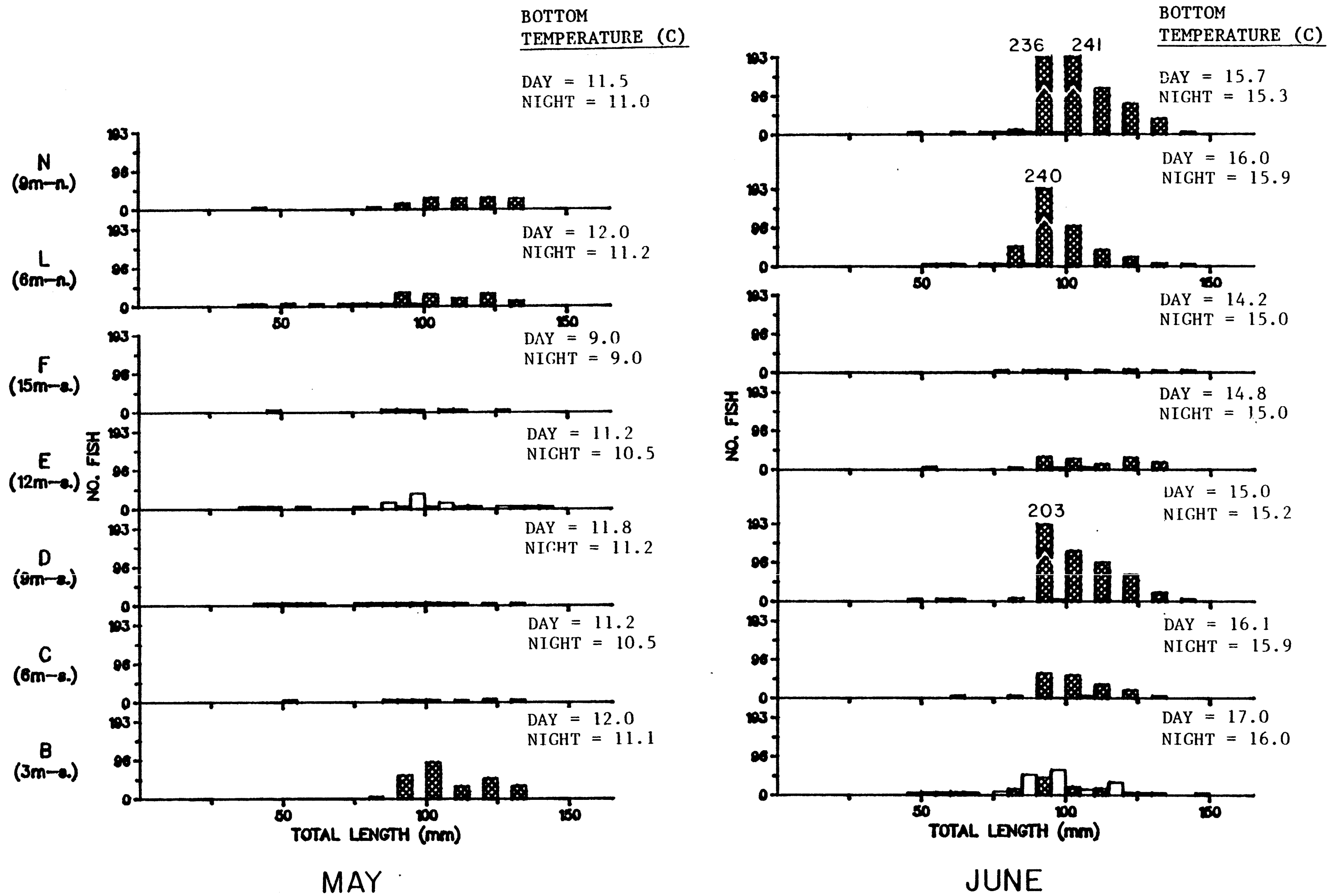
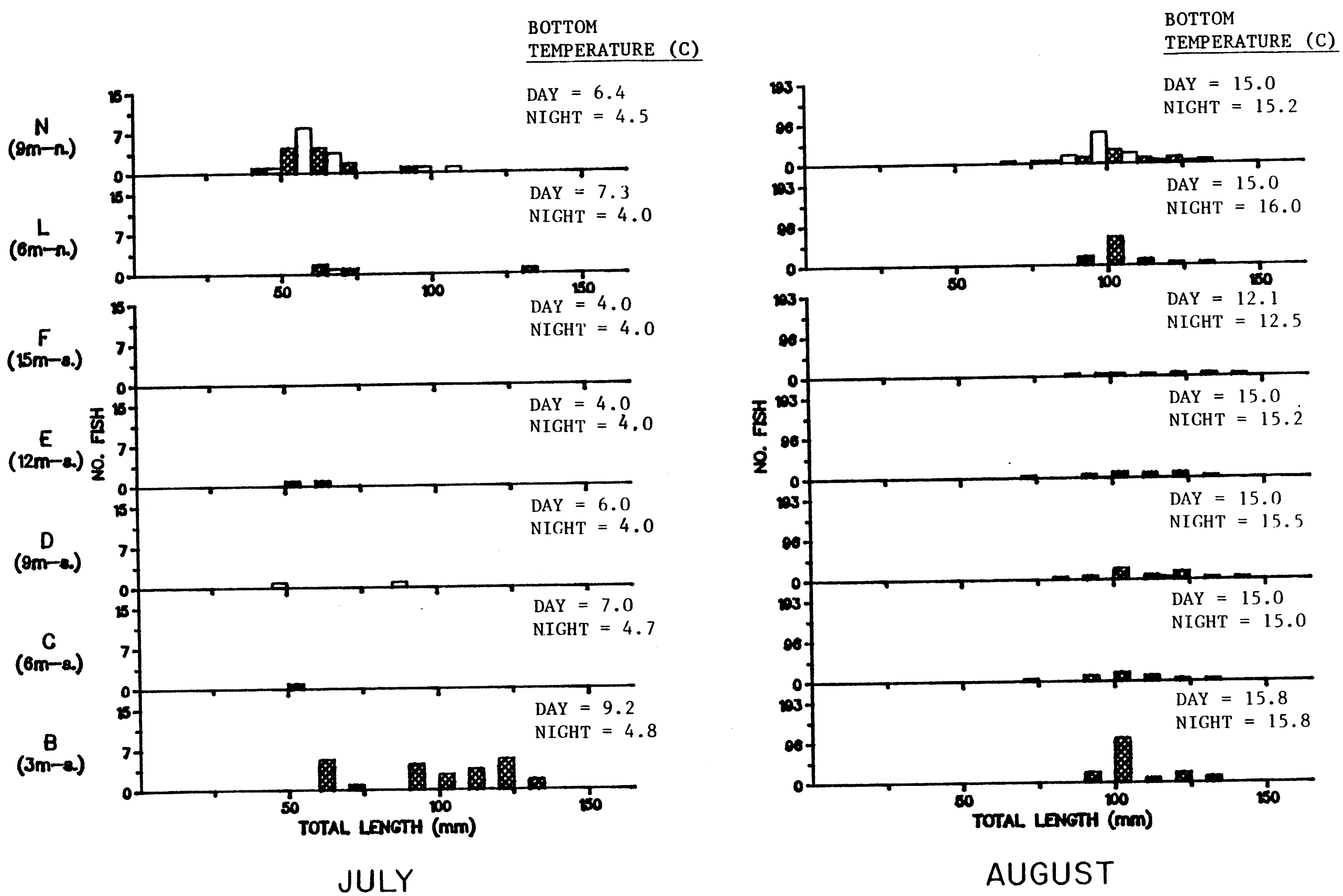


Fig. 28. Length-frequency histograms for spottail shiners caught in duplicate trawl hauls during April to December 1979 in Lake Michigan near the J.H. Campbell Plant, eastern Lake Michigan. □ = day ■ = night * = no day sampling performed.



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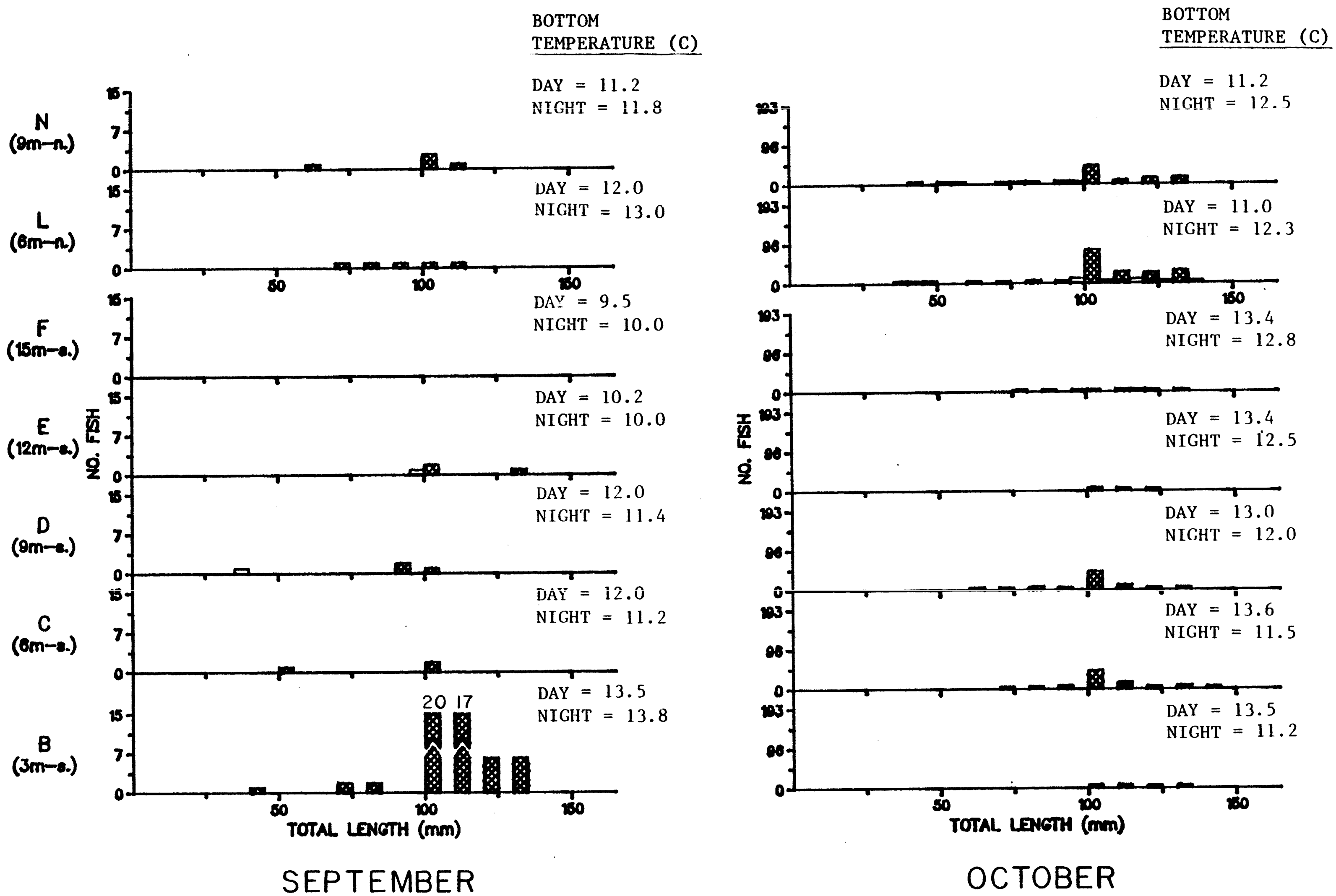

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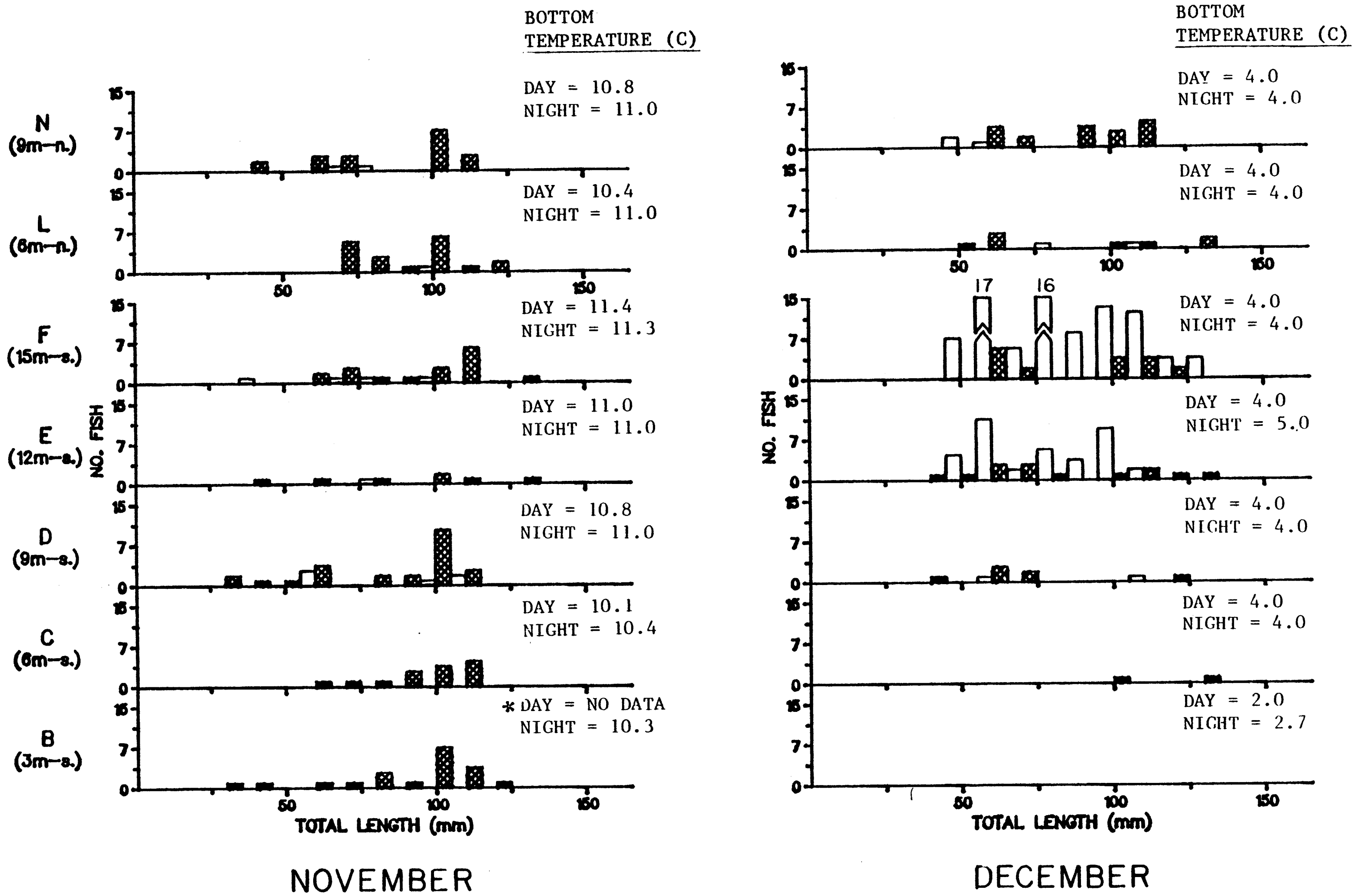

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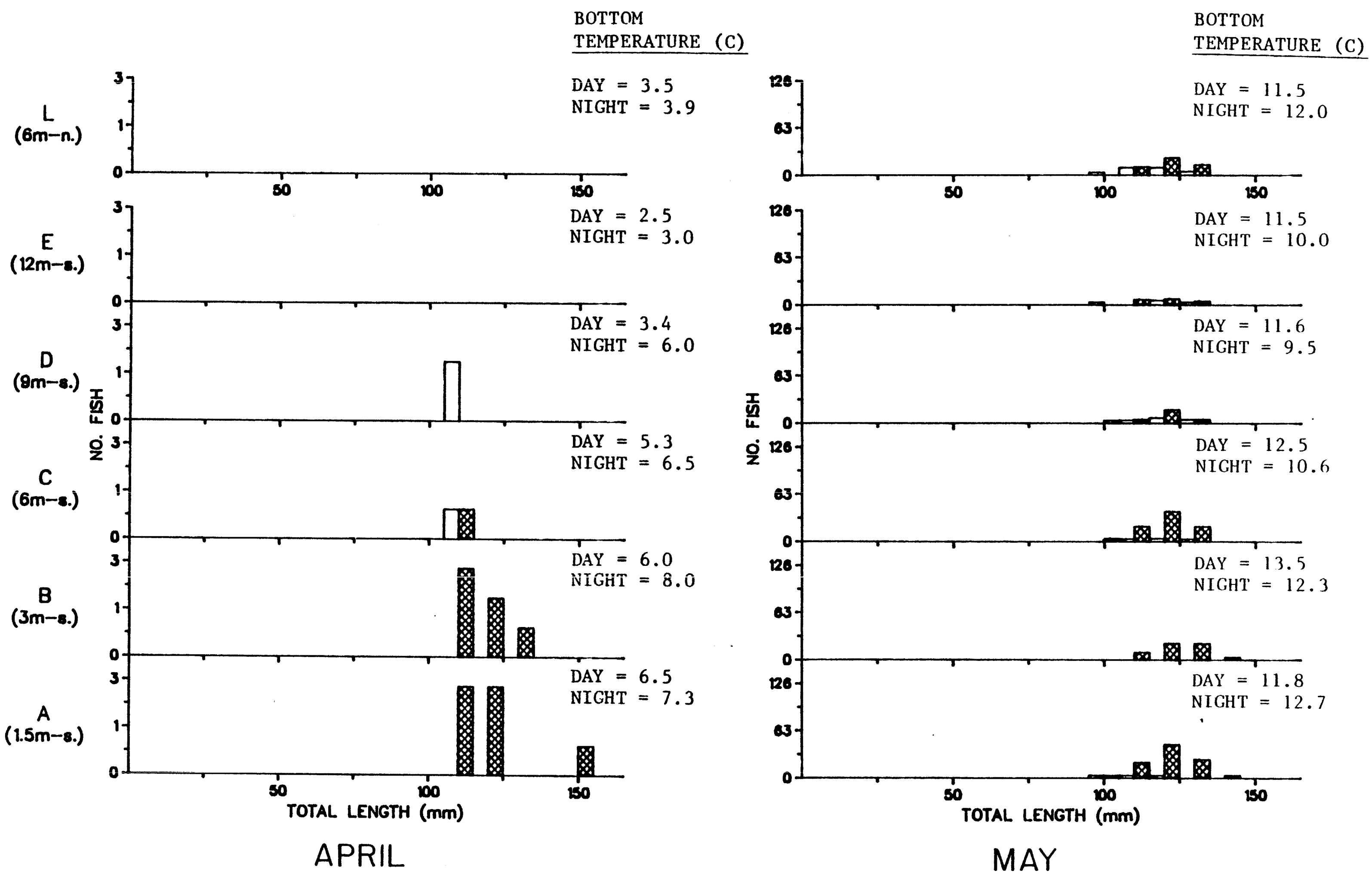
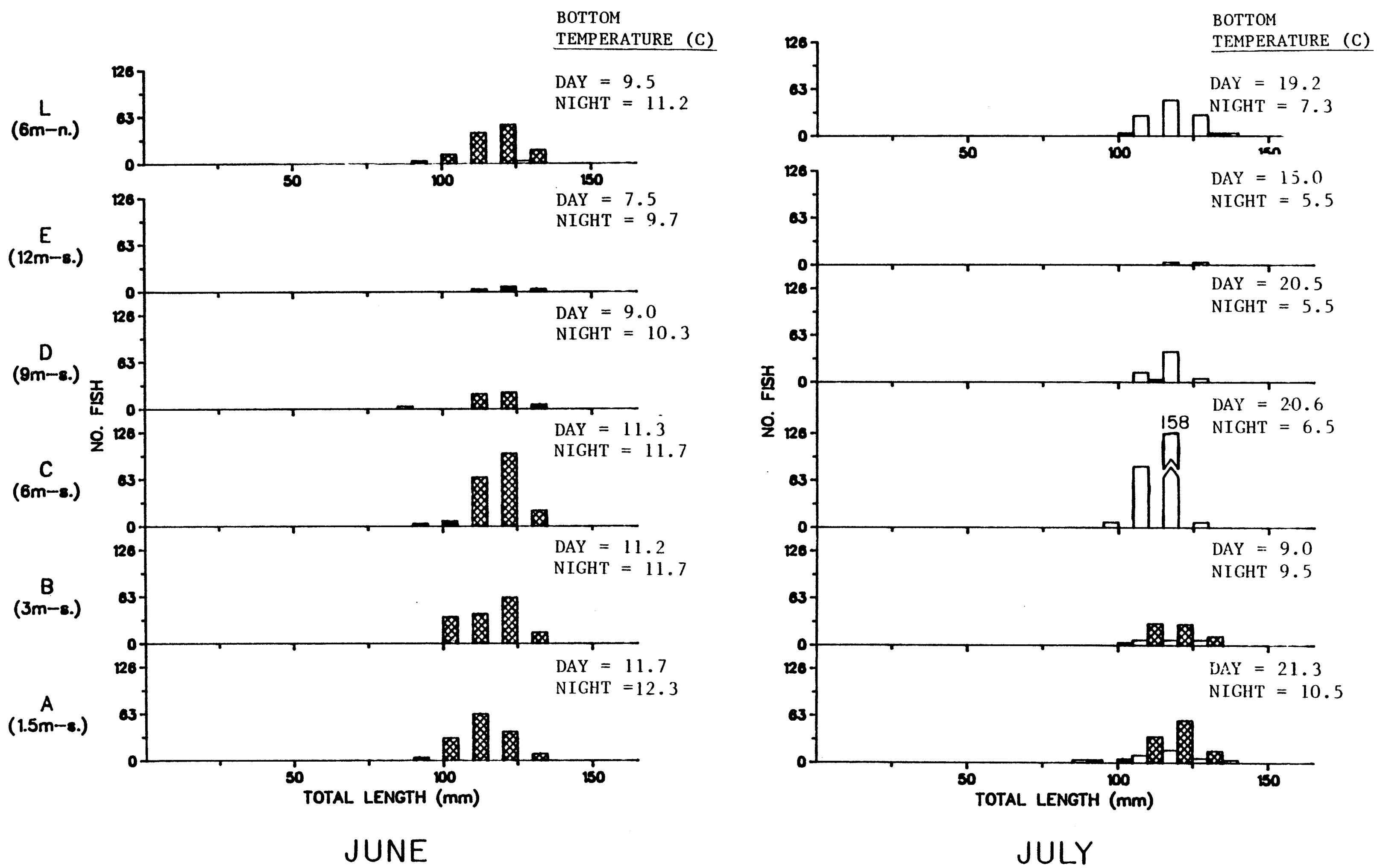


Fig. 29. Length-frequency histograms for spottail shiners caught in duplicate bottom gill nets during April-November 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. ☐ = day ■ = night + = no sampling done.



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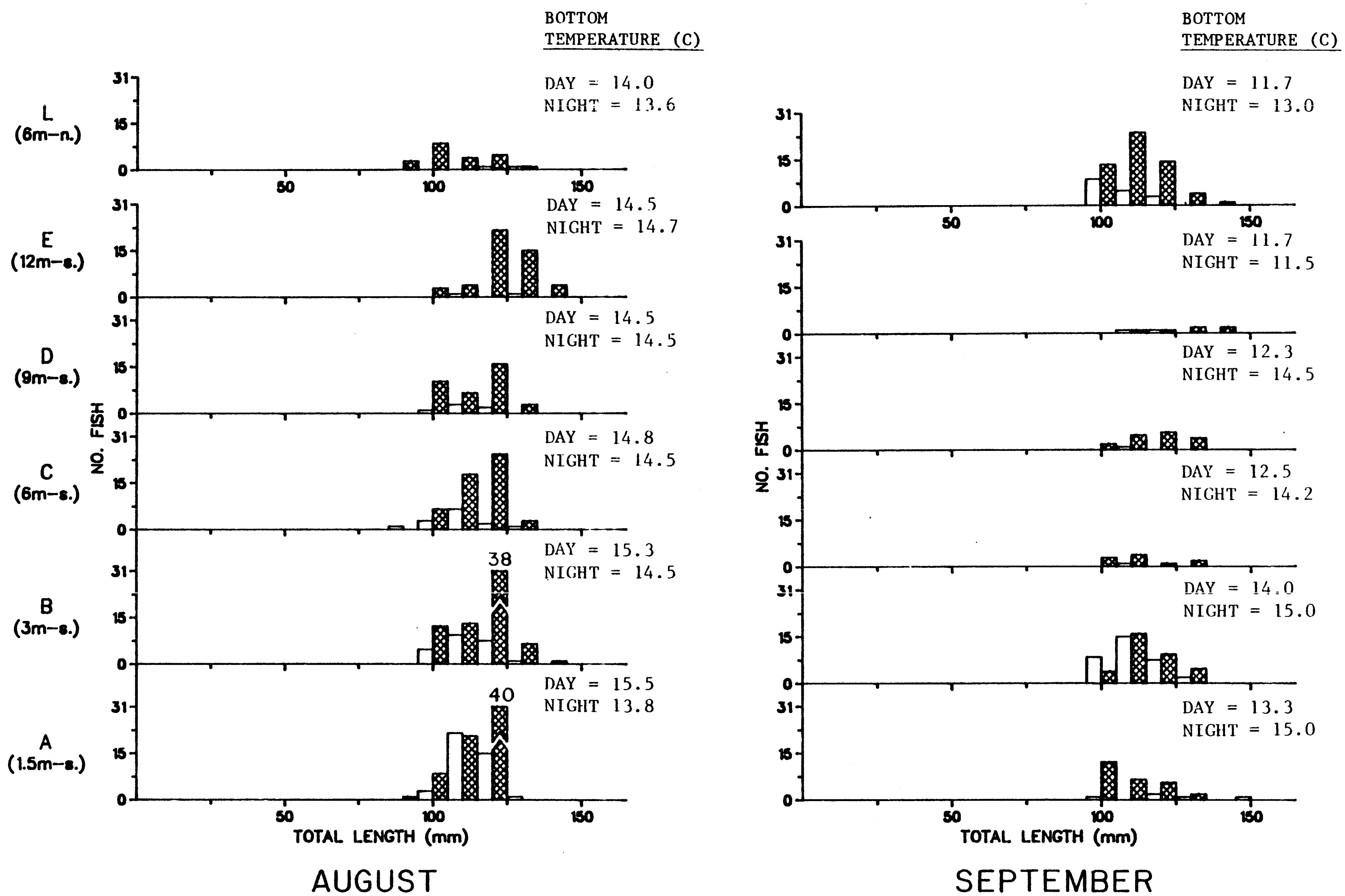

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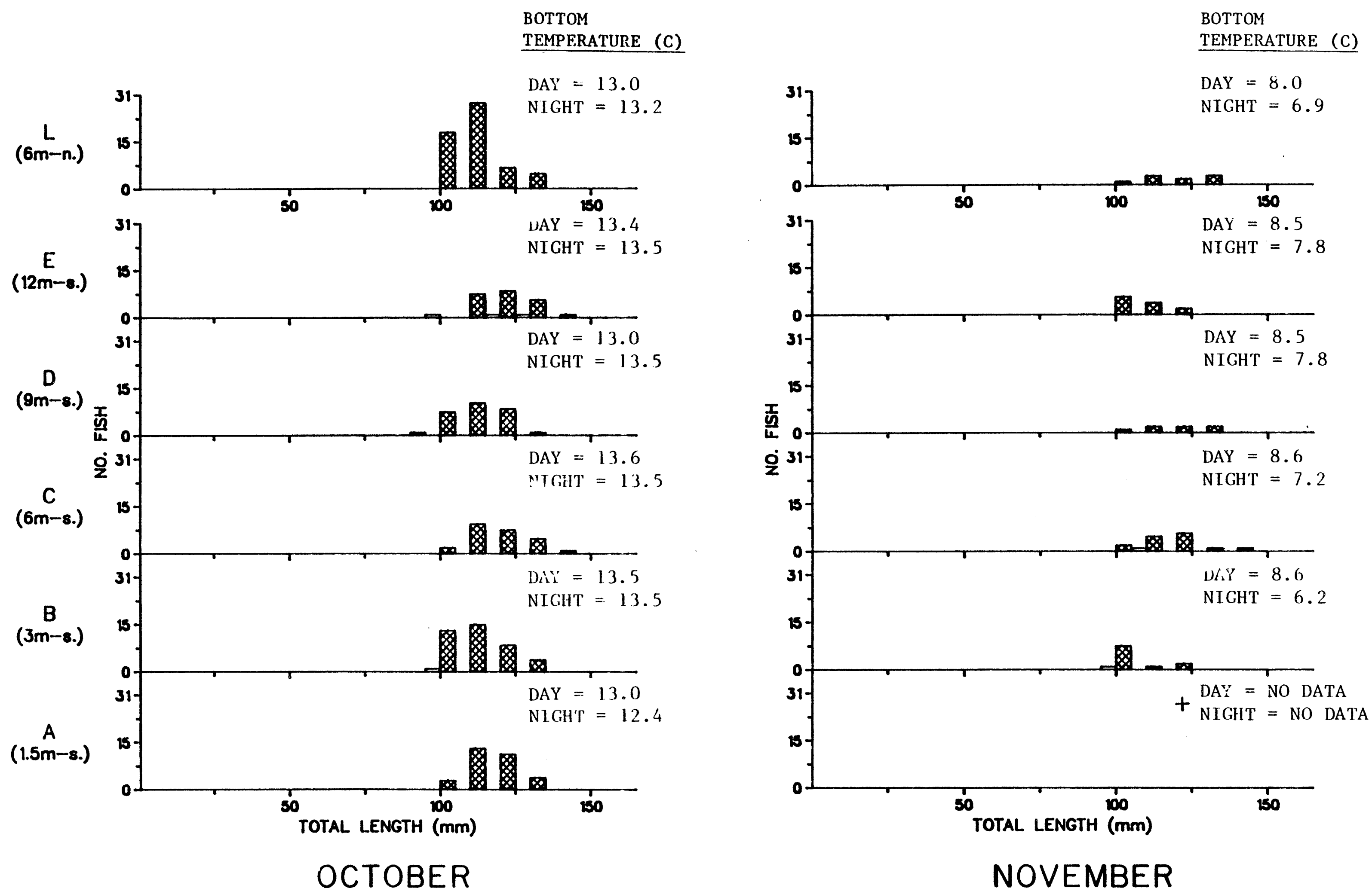

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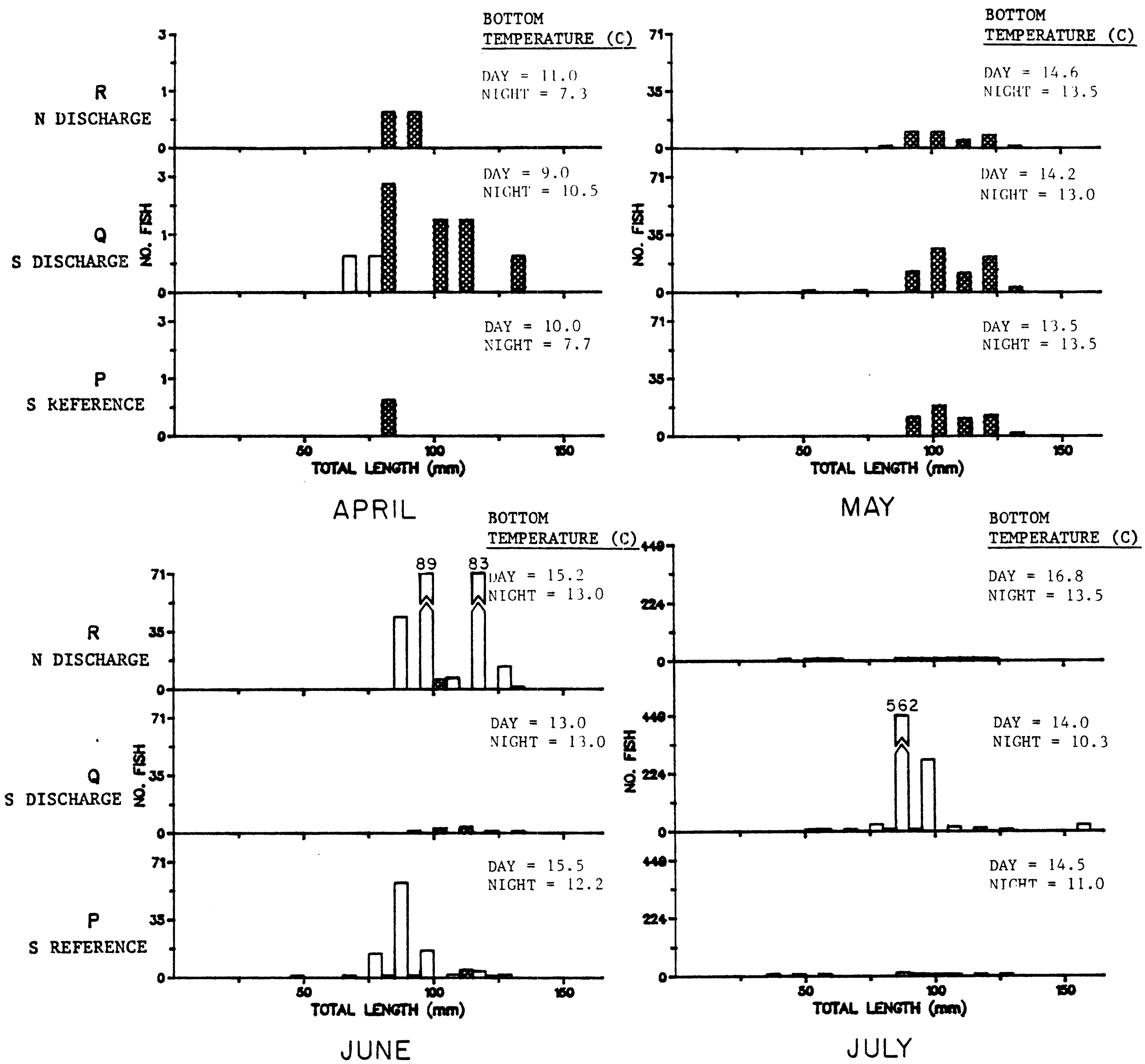
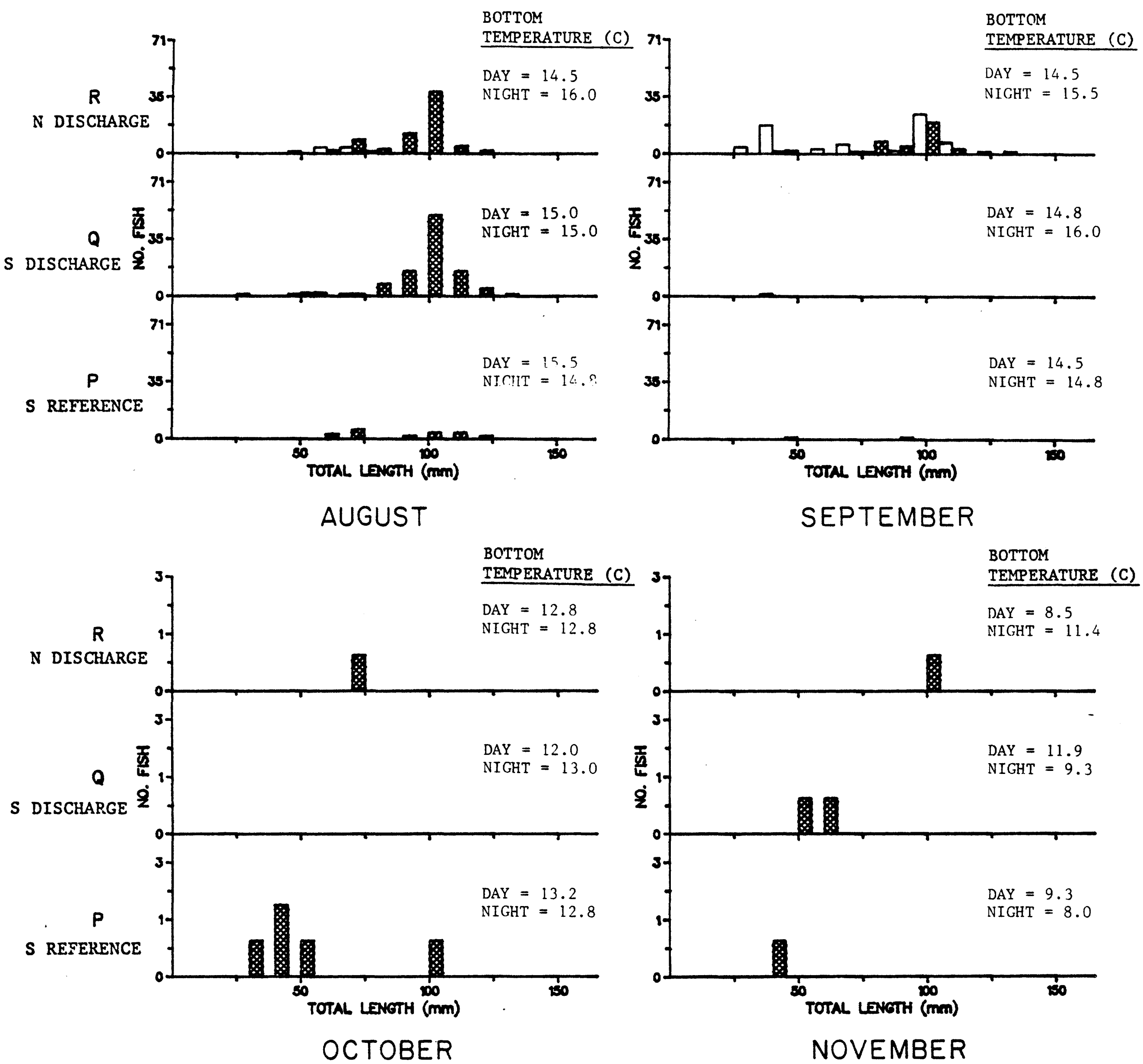


Fig. 30. Length-frequency histograms for spottail shiners caught in duplicate seine hauls during April to November 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. □ = day ■ = night.



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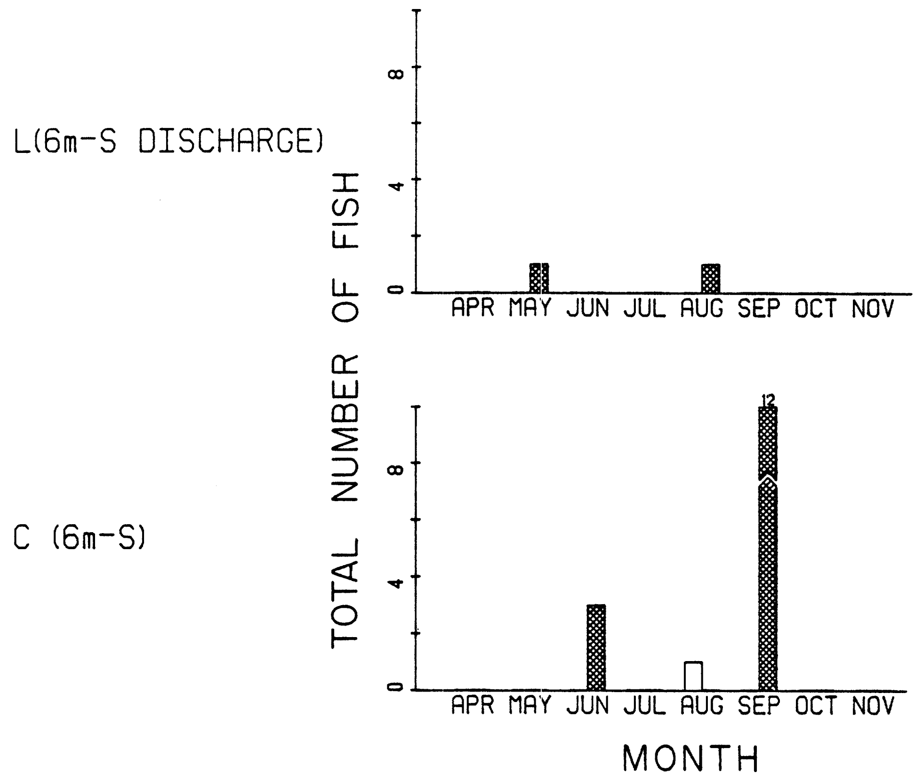


Fig. 31. Total number of spottail shiners caught in duplicate surface gill nets fished during day and night once per month April to November 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. □ = day ■ = night.

Table 23. Monthly gonad conditions of spottail shiners caught during 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. All fish examined in a month were included except poorly received specimens.

	Gonad condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Slight development	10	127	24	37	206	95	170	58	41
	Mod. development	4	140	75	25	34	3	12	24	13
Males	Well developed	4	22	56	23	4				
	Ripe-running			1	9					
	Spent		2	58	49	6	6			
	Slight development	1	66	8	5	170	95	138	31	23
	Mod. development	7	235	75	12	61	16	41	52	29
Females	Well developed	3	67	375	64	5			2	
	Ripe-running			37	18					
	Spent		4	47	40	4	4			
	Absorbing		2	5	2	10	9	4		
Immature		1	42	43	69	42	31	41	34	73
Unable to distinguish		1	17	81	70	169	57	47	18	11

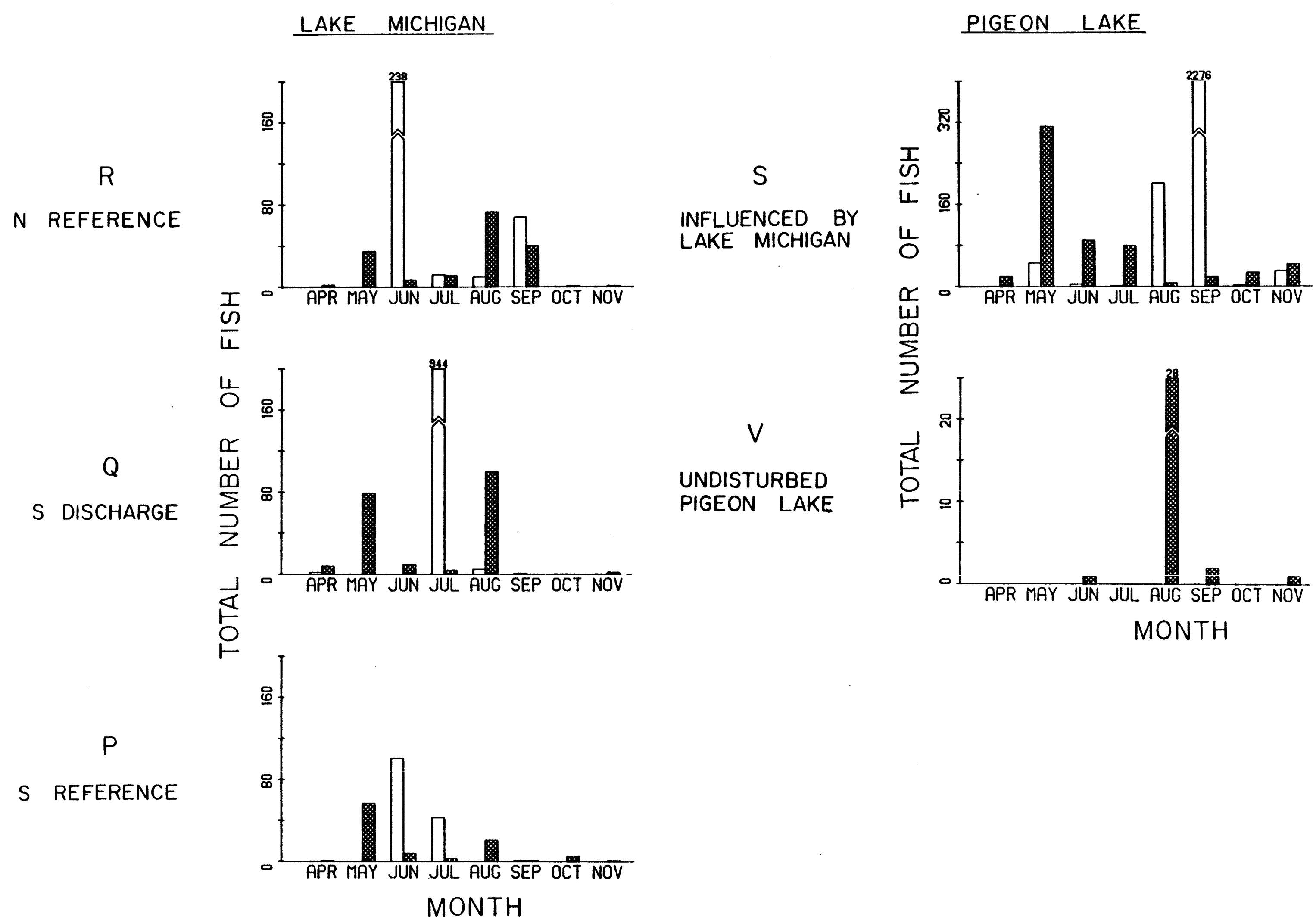


Fig. 32. Total number of spottail shiners caught in duplicate seine hauls during day and night once per month April to November 1979 in Lake Michigan and Pigeon Lake near the J. H. Campbell Plant, eastern Lake Michigan. □ = day ■ = night.

June--By June, spottails completed their inshore movement with maximum densities observed at 6 m. Many were also found in the beach zone. Peak abundance of spottail shiners in Lake Michigan collections occurred in June with a catch of 3442 fish. Nearly all (99%) were adult fish (75-155 mm). Jude et al. (1979b) reported that a major inshore movement of adult spottails occurred during May and June in southeastern Lake Michigan off Bridgman, Michigan. In contrast to June 1977 and 1978 when numbers of spottails caught in bottom trawls were low (Jude et al. 1978, 1979a) 70% of the June 1979 catch was collected in bottom trawls (Fig. 28). As would be expected, most trawled fish were caught at night. Trawling data indicated that spottails preferred the 6- to 9-m depths with 81% of the catch taken there. Water temperatures at the bottom were nearly homothermous throughout the study area (14.8-17.0 C) suggesting that temperature did not have much effect upon distribution, at least in June.

Bottom gill nets accounted for 679 spottails during June. Maximum numbers were caught at 6 m (Fig. 29). Sizeable catches of adults (100-135 mm) were also taken at 1.5 and 3.0 m. These fish were most likely inshore to spawn. Gonad data (Table 23) suggest that spawning took place during June and July 1979. Spottails spawned during the period May-August in Lake Michigan during 1978 (Jude et al. 1979a). Presence of small (< 8 mm) larvae indicates that spawning activity was ongoing during June in Lake Michigan (see FISH LARVAE AND FISH EGGS-Spottail Shiner). Highest concentrations were found at 3 m or less. The large adults at the beach stations, 1.5-m bottom gill net stations and the 3-m trawl and bottom gill net stations, had moved inshore to spawn.

Beach seining in June (Fig. 30) accounted for 364 spottails, 238 were caught at the north discharge beach station R, 109 at south reference beach station P and only 10 at south discharge station Q. The north discharge station accounted for a majority of the entire June sampling effort during 1977 and 1978 (Jude et al. 1978, 1979a). All but 25 of the spottails seined during June were caught during the day. They were all adult fish (> 90 mm) and probably stayed in the beach zone during the day because of spawning activities. Jude et al. (1979b) reported similar findings in southeastern Lake Michigan off Bridgman, Michigan during 1974.

Numbers of spottail shiners caught in Pigeon Lake during June 1979 increased slightly over June 1978 (96 vs. 79). Size range of these fish, 75-135 mm, indicated that they were all adults. All but one fish were caught at Lake Michigan influenced station S. Occurrence of sizeable densities of spottail larvae in Pigeon Lake during June and July suggests that spawning activity was ongoing during June.

July--The distribution of spottail shiners in Lake Michigan during July 1979 was quite similar to their July distribution during 1978 and 1977. During all 3 yr, large numbers of spottails appeared in beach seine hauls and moderate numbers of fish were caught in bottom gill nets (except in 1977 when few were caught); few were collected in bottom trawls.

A diurnal activity pattern for spottails was evidenced by beach seine data. Of the 1014 (mostly adult) spottails caught in seine hauls, only 18 were caught at night. As in 1978, the largest catch (948 fish) was taken at south discharge station Q; all but 4 were caught during the day. Water temperatures were the warmest at the beach stations during the day. At station Q, day water temperature was 12.5 C in contrast to 10.3 C during the night suggesting spottails preferred warmer water. Spawning activity may also account for the presence of spottails in the beach zone during the day. Gonad development data (Table 23) indicate that spawning activity was ongoing during July in Lake Michigan. Jude et al. (1979b) reported collecting large numbers of adult spottails in the beach zone during the spawning season in southeastern Lake Michigan during 1973 and 1974. Anderson and Brazo (1978) reported finding large concentrations of spottails in the beach zone during the day in June in east-central Lake Michigan. It is possible that spawning activity occurs chiefly during the day in southeastern Lake Michigan.

Spottail shiners, as exhibited by bottom gill net catches, showed a diurnal activity pattern; 675 fish were caught during the day and 189 at night (Fig. 29). These fish were mostly adults 105-135 mm. Most of the catch (89%) was collected at 6 m or less. Gill net catches at shallower stations (1.5 and 3 m) were highest during the night (Fig. 29). In contrast to the large number of fish caught in bottom trawls during June (2396), few were trawled in July (67 - Fig. 28). Few spottails were caught in trawls during June 1977 and 1978.

As in June, adult spottail shiners (85-105 mm) were seined at night in Pigeon Lake; all were caught at station S (Lake Michigan influenced). It is suspected from the occurrence of spottail larvae at this station in late July and August (see FISH LARVAE AND FISH EGGS-Spottail Shiner), that spawning activity was still occurring during July 1979. During July 1978 large numbers of YOY spottails were collected at station S, while no YOY fish were caught during July 1979; larval spottails were not caught at station S until late July. Water temperatures were quite similar at station S during the period April-June during 1978 and 1979 indicating that this variable was not responsible for the lack of YOY spottails at this station in July. Peak spawning may have occurred earlier in 1978, but the reason for this is not known.

August--Total catch of spottail shiners for August 1979 was 1315 fish which was the lowest catch for August during the 3 yr of our study; 1444 and 3471 were caught during 1977 and 1978, respectively. In contrast to July, most spottails were caught at night in August.

Spottails caught in beach seine hauls in Lake Michigan ranged in length from 25 to 135 mm, but most (74%) were between 65 and 105 mm. Most fish caught in beach seines in July were larger (85-145 mm). Gonad development data (Table 23) indicated that spawning activity most likely came to a halt in August after peaking in July. Larger adults were not as abundant in the beach zone in August because of post-spawning mortality and migrations from the shallow-water area.

Trawl data from August (Fig. 28) showed that spottails were distributed throughout the study area during this period. The smallest catch (25 fish) was taken at 15 m. Water temperature was 12.1 C, the coldest water of all trawling stations. Temperatures at the 1.5- to 12-m stations ranged between 15.8 and 15.0 C. Spottails were randomly distributed throughout this warm water zone with peak catches at 1.5 m (177 fish) and 6 m-north (110 fish). Jude et al. (1978) reported that spottail shiners prefer the warmest water available. Bottom gill net data showed that spottails were distributed throughout the study area (Fig. 29). The catch was 89% adult fish between 95 and 125 mm. Over half of the largest spottails (> 125 mm) were caught at 15 m. At beach stations 79% were ≤ 104 mm. Wells (1968) found larger spottails in deeper water during most of the year in southeastern Lake Michigan. Water temperatures were quite uniform throughout the study area at the time of our gill net sets (13.5-15.5 C) precluding any thermal preference determinations.

First appearance of YOY spottail shiner occurred during August in Pigeon Lake. Of the 236 spottails seined in Pigeon Lake (208 at Lake Michigan influenced station S and 28 at undisturbed station V), 84% (198 fish) were YOY with a size range of 10-45 mm. Only one adult fish was caught in Pigeon Lake during August.

September--Total catch (all gear) of spottails in Lake Michigan declined considerably from the levels of the preceding 4 mo. Only 417 spottails were caught in September, down from 1313, 3442, 1748 and 1315 caught during May, June, July and August, respectively. A similar pattern was documented during September 1978 (Jude et al. 1979a). In contrast to 1978 and 1979, the September catch in 1977 was the largest (4018 fish) of the year (Jude et al. 1978). Most fish caught in Lake Michigan during August 1977 were YOY caught in beach seines. Because of general cold water temperatures during the spawning season (Appendixes 1, 2 and 3), high egg and larval mortality may have occurred which resulted in the low numbers of YOY spottails caught in Lake Michigan during September, October and November 1979. It is also possible that YOY moved from the beach zone and therefore were not susceptible to our sampling gear.

Bottom gill nets accounted for the largest catch among gear types during September (217 fish). Eighty-three percent (180 fish) were caught at 6 m or less (Fig. 29). Bottom gill net data from 1978 (Jude et al. 1979a) showed a similar concentration of spottails at 6 m or less.

Of the 77 spottails caught in bottom trawls in September, 56 (73%) were caught at 3 m. This station had the warmest water temperature (13.8 C) of all trawling stations (Fig. 28). Temperature preference is most likely the reason for the abundance of spottails at this station. Trawl data from 1978 showed a selection for the 3- and 6-m stations where the water was warmest. Wells and House (1974) reported a mean length of 63 mm was attained by spottails during their first year of growth in southeastern Lake Michigan.

Beach seines accounted for 111 spottails during September; all but 8 were caught at north discharge station R. Nearly all, 89%, were YOY or juvenile fish (25-105 mm). Price (1963) reported that spottails in western

Lake Erie grew to 80 mm in their first year. Seine hauls indicated that adult spottails had vacated the beach zone by September. A similar trend was described in our 1978 study when most of the spottails caught in seines were at station R.

As was observed in 1977 and 1978, the largest catch of spottails in Pigeon Lake for any month was taken in September. As in the previous years, YOY and a few yearlings made up the catch of 2297 spottail shiners. All but two were caught at Lake Michigan influenced beach station S (Fig. 32), once again demonstrating the preference of Pigeon Lake spottails for this area and its importance as a nursery area.

October--Numbers of spottails caught in Lake Michigan during October (783 fish) increased compared with September catches (417 fish). During 1977 and 1978, a decrease in catch was observed from September to October. The fact that water temperatures were about the same (11.0-13.5 C) in October as in September (11.7-14.0 C) may have somewhat delayed the annual fall migration to deeper water exhibited by spottail shiners in southeastern Lake Michigan. Wells (1968) and Jude et al. (1979a,b) documented this phenomenon.

As in 1977 and 1978, spottails were virtually absent from the beach zone in October; 52 and 19 were seined during October of those years. Only six spottails were seined in October 1979. Bottom trawls accounted for 71% of the October catch (557 fish); 81% were trawled at 6 m and 9 m. Of the trawled fish, 87% were juveniles and adults (size range 95-145 mm). During 1977, trawl data showed that spottails were most abundant at 6 and 9 m with most being small adults or yearlings.

Bottom gill net catches were comprised of larger adult spottails; 87% were 105-145 mm. Catches were uniformly divided between the 1.5-, 3-, 6-, 9-, 12- and 15-m stations (Fig. 29). The largest catch (60 fish) was taken from the 6-m north station. As mentioned earlier, water temperatures showed only minor variations in the study area during October and spottail movements showed little relationship to this variable.

As was observed in Lake Michigan, spottails had begun to vacate the beach zone in Pigeon Lake in October. Only 30 spottails were seined at Lake Michigan influenced station S; none were caught at Pigeon Lake undisturbed station V. All fish seined in October were YOY (25-70 mm); very few spottails were seined in Pigeon Lake during 1977 and 1978.

November and December--Although the bulk of the Lake Michigan spottail population was probably in water deeper than 15 m, some fish were in the study area during November and December since 219 and 206 were caught, respectively. During November, 140 fish, mostly YOY and juveniles (35-115 mm), were caught in bottom trawls (Fig. 28). Fish were uniformly distributed throughout the trawl stations. Bottom gill nets showed a distribution of spottails similar to trawl catches; 75 fish were caught. All were juveniles or small adults with a size range of 85-125 mm (Fig. 29). During December 80% of the catch was collected from the deepest trawling stations (12 and 15 m); nearly all fish were YOY or juveniles (45-110 mm) indicating that this size class was the last

to migrate to deeper water. This same spatial distribution was found in Lake Michigan during November and December 1977 and 1978 when mostly YOY fish (25-50 mm) were caught in the study area. In Pigeon Lake some YOY spottail were seined during November (Fig. 28).

Temperature-catch relationships--Over 85% of our spottail catch in Lake Michigan was collected in water at temperatures of 11 to 15 C (Fig. 33). Water temperature remained relatively cool during 1979 (Appendixes 1, 2 and 3) compared to previous years; temperatures very seldom were higher than 16 C during any sampling period. Although no relationship between spottail size and catch temperature was noted in 1979, it appears that spottails selected the warmest water available to them. During 1977 we collected 69% of our spottails between 11-17 C. A wider range was observed in 1978 when 81% of the spottails were caught at mean temperatures of 15-23 C.

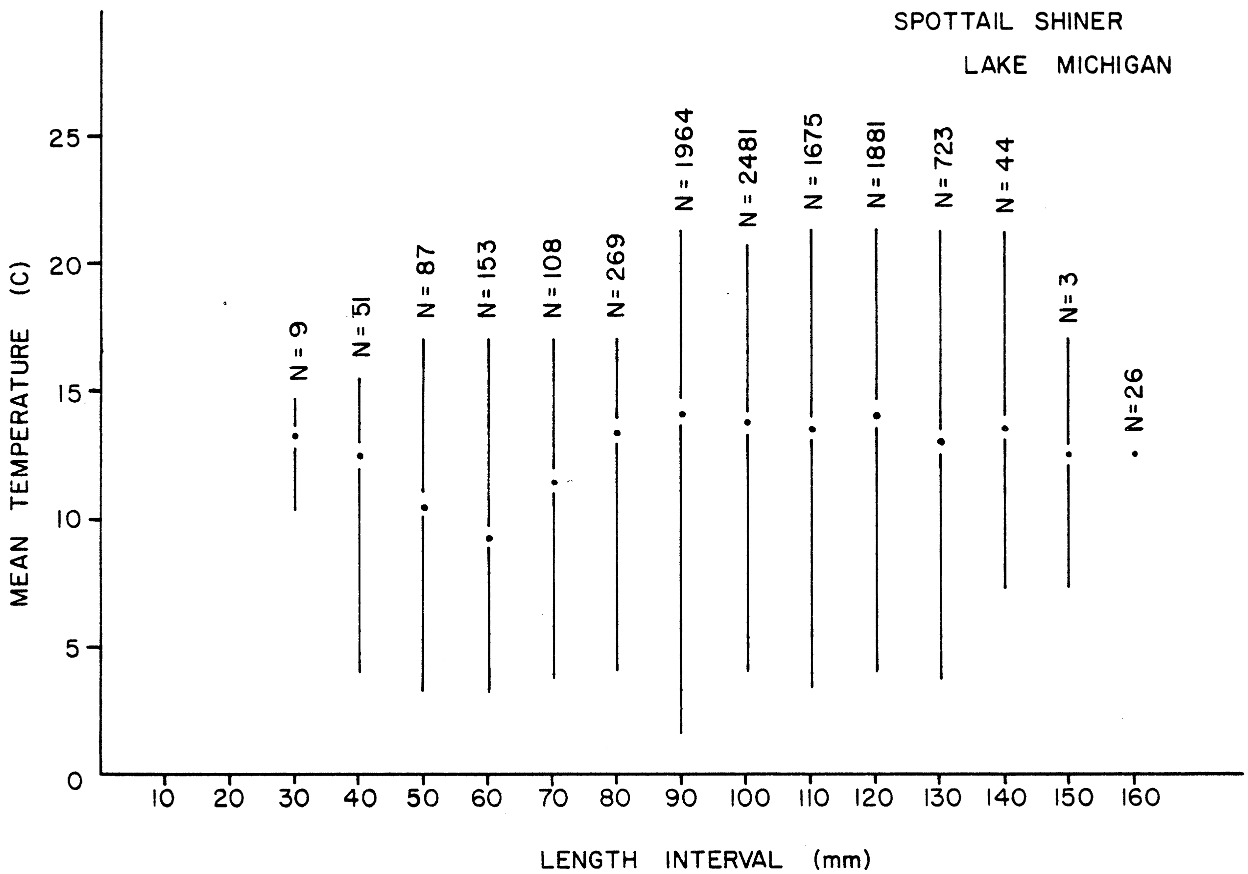


Fig. 33. Weighted-mean temperatures at which various sizes (10-mm length groups) of spottail shiners were collected by all gear types from Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan, 1979. Vertical bars represent the range, N = number of fish.

Impingement--Spottail shiners were the third-most abundant species impinged during both 1978 and 1979. In 1979, 6111 spottails were impinged at the Campbell Plant, 4.5% of the yearly impingement total for all fish. This represents a slight increase over 1978 when 5673 spottails were impinged. March was the month of maximum spottail impingement. Because they are not common in the nearshore water of Lake Michigan during March, these fish were most likely Pigeon Lake residents. An estimated 1571 spottails were impinged in March. These fish were mostly juveniles and small adults (75-125 mm). In July an estimated 1472 spottails were impinged; all were adult fish (85-135 mm). Field samples indicated that spottails were spawning in the inshore areas of Lake Michigan and Pigeon Lake during July and were more vulnerable to impingement during this period. Spottail shiners were impinged most often during March, July and August 1974 at the Cook Plant (Jude et al. 1979b) in southeastern Lake Michigan.

Plant impacts--In comparison to alewives and smelt, spottail shiners are not an important forage species in Lake Michigan. No spottails were found in the stomachs of lake trout, brown trout, rainbow trout, coho salmon or chinook salmon caught in our nets during 1979. Because of their preference for warm water, it is unlikely they would ever become important prey for the salmonids. They would be well suited for walleye forage, but walleyes are not common in southeastern Lake Michigan. The yellow perch stomachs examined contained no spottail shiners. During 1979, in excess of 8 million spottail larvae were entrained at the J. H. Campbell Plant which is a dramatic increase over the 25,800 entrained in 1978; 6111 spottails were impinged, a slight increase over the 5673 impinged in 1978. Part of the increase in entrained spottail larvae is due to our increased expertise in cyprinid identification drastically reducing the number of cyprinids classified as unknown minnows (XM). During 1978 2.93 million unknown minnows, most of which were believed to be spottails, were entrained. For the period 1977-1979, spottail shiner populations have remained relatively stable in both Lake Michigan and Pigeon Lake. Lake Michigan catches declined somewhat in 1979, but were still higher than 1977 catches. Pigeon Lake catches increased in 1979, but were lower than the 1977 catch. An evaluation of the effects of the plant on spottail shiner populations is mainly a function of the magnitude of larval entrainment and impingement of juveniles and adults. Because spottails are not an important forage species and not harvested by a commercial or sport fishery in eastern Lake Michigan, impingement losses due to the plant will probably have a minimal effect on the piscivorous fish in Lake Michigan. The large increase in larval spottail entrainment could very well be attributed to an increase in spawning activity in the intake canal. The intake canal is the site of a considerable amount of spawning by many fish species and also serves as a nursery area. We suspect that many of the spottail larvae entrained are a result of production in the intake canal and not from Lake Michigan and Pigeon Lake populations (see FISH LARVAE AND FISH EGGS-Cyprinidae Complex and YEARLY ENTRAINMENT SUMMARY). SCUBA observations in the intake canal documented the presence of large schools of larval and YOY spottail shiners.

Summary--Spottail shiners were the third-most abundant species caught in both Lake Michigan (12.1% of entire catch) and Pigeon Lake (17.0% of total catch) during 1979. Spottails were caught during every month in which fishing occurred. In Lake Michigan, a shoreward migration began in April and continued until peak abundance was reached in June; Lake Michigan spottails spawned from May to August with peak activity in June and July. In Pigeon Lake spottails spawned from May to July. Peak abundance was reached in September when large numbers of YOY were collected. They were present in modest numbers through November.

In Lake Michigan catches decreased during July and August as adults began dispersing after spawning. A decline in catch during the fall was observed as spottails began their migration to deeper water. Adults were nearly absent from the study area in November. YOY and yearlings were the last to leave the study area. A decline in numbers of YOY was observed during 1979.

Yellow Perch--

Introduction--Yellow perch is a highly adaptable and widespread percid fish, occurring throughout most of North America. With the closely related Eurasian perch, it presents an almost circumpolar distribution in northern latitudes (Scott and Crossman 1973). Its habitat includes a wide variety of water, including large and small clear lakes and quiet rivers with moderate vegetation. In the Great Lakes yellow perch are most abundant in protected bays, such as Green Bay on Lake Michigan and Saginaw Bay on Lake Huron, and are common in shallower areas at depths up to 40 m (Wells and McLain 1973). Kitchell et al. (1977) compared percid lake habitat to that of large temperate rivers with shallow to moderately deep zones and extensive littoral and shoreline areas, characterized by sand or gravel substrates, submerged vegetation, low current velocity, temperatures conducive to spawning and growth and well oxygenated spawning substrates. They concluded that spawning requirements are most often the critical element for yellow perch success in large lakes.

Yellow perch have been important in Lake Michigan as a commercial species since the 1880s and as a sport fish since at least the 1920s (Wells 1977). Population levels have fluctuated greatly over the years, with a general decline in the 1960s; however, data from sport fishery catches in southeastern Lake Michigan indicate increased catches from 1970 to 1975 (Wells 1977).

Despite decline in catch from previous years, yellow perch remained the sixth-most abundant species in Lake Michigan field samples in 1979, comprising 0.8% (605 fish) of the total Lake Michigan catch. Yellow perch were most often caught in trawls (378 fish) and bottom gill nets (218 fish), with only four yellow perch taken in seines and five in surface gill nets. Catch for each gear was lower in 1979 than in 1978, except for surface gill nets which had not taken any yellow perch in 1977 or 1978.

In contrast, yellow perch catch in Pigeon Lake increased dramatically due to exceptionally large catches of YOY in seines. Yellow perch were the most abundant species taken in Pigeon Lake, comprising 43.7% (8195 fish) of the total catch. Gill net catches totaled only three fish, which were taken in day sets in April. Further gillnetting in Pigeon Lake was eliminated due to conflicts with construction activities. Absence of gill net data reduces our ability to discuss depth distribution of fish in Pigeon Lake and interactions of Lake Michigan fish with Pigeon Lake fish in the area of mixing at 6-m station M.

Proximity of a small quiet river and small lake system (Pigeon Lake) and the much larger Lake Michigan system presents a conjunction of two habitats with many features conducive to yellow perch populations. Interaction between the two systems due to river flow from Pigeon River through Pigeon Lake to Lake Michigan and man-induced flow from Lake Michigan through Pigeon Lake to the Campbell Plant for cooling purposes presents considerable opportunity for interaction between fish populations in the two systems. However, previous observations (Jude et al. 1978, Jude et al. 1979a) indicated distinct patterns of life history in the two systems. Spawning occurred earlier in Pigeon Lake (late April-early May) than in Lake Michigan (late May-early June) in 1978. Differences in lake morphometry force differences in bathymetric distribution of fish; maximum depth of Pigeon Lake is 7 m while depths up to 46 m (25 fathoms) are utilized by yellow perch in Lake Michigan (Wells 1968). Additionally, different sources of water flow and responses to weather produce distinctly different conditions between the two systems. Due to these factors, seasonal abundance and distribution of yellow perch will be described separately for the two systems, but cross referenced as parallels or contrasts are elucidated. Discussion of impingement and entrainment losses will follow, with consideration of from which water system impinged yellow perch originated. Temperature-catch relationships will be discussed in regard to seasonal abundance of yellow perch in the two systems.

Seasonal Distribution - Lake Michigan--

April, May--Yellow perch were not abundant in inshore waters in early months of 1979. Only 25 yellow perch were caught, 12 in April and 13 in May. Almost all fish were taken at night at stations from 6 to 12 m, about half in trawls and half in gill nets (Fig. 34). Only one yellow perch was taken in seine hauls (Fig. 35). Within the 6-12-m depth zone, fish were distributed sporadically among stations and by length in trawls (Fig. 36) and bottom gill nets (Fig. 37).

The almost random occurrence of yellow perch in night samples and absence from day samples corresponds well with diel patterns observed in other studies. Adult yellow perch tend to school and move offshore by day, but disperse and move inshore at night, resting on or near bottom (Hasler and Villemonte 1953; Emery 1973; MacLean and Magnuson 1977). Thus sampling in April and May 1979 indicated yellow perch were maintaining daytime positions beyond the 15-m depth contour, and dispersing shoreward to 6 m by night. Similar distributions of yellow perch were found in studies in eastern and southeastern Lake Michigan (Jude et al. 1979a, Jude et al. 1979b). Brazo et

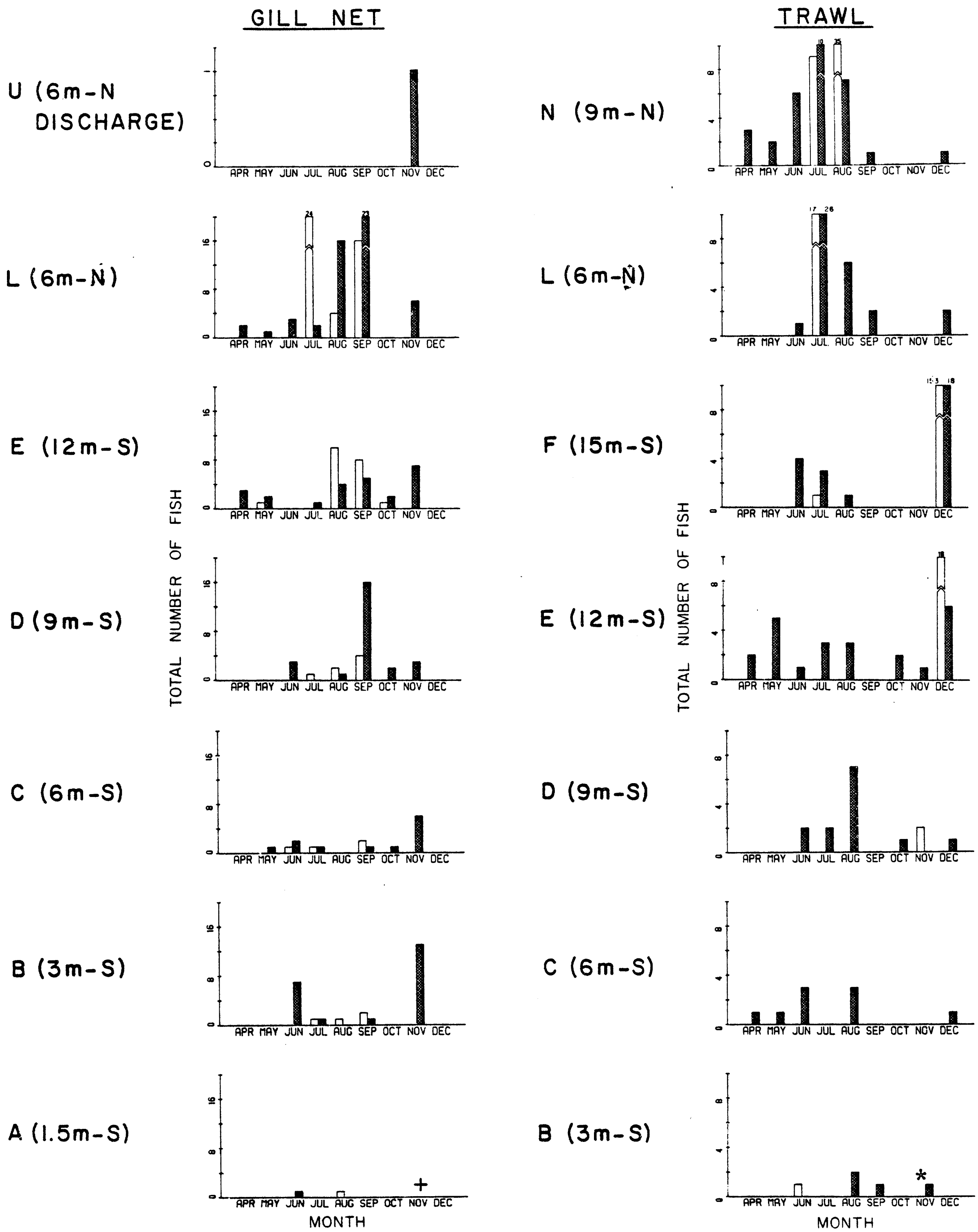


Fig. 34. Total number of yellow perch caught in duplicate bottom gill nets (left column) and duplicate trawl hauls (right column) during day and night once per month in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. Bottom gill nets were fished April to November 1979, trawl hauls were done April to December 1979. ☐ = day ■ = night * = no day sampling performed + = no sampling performed.

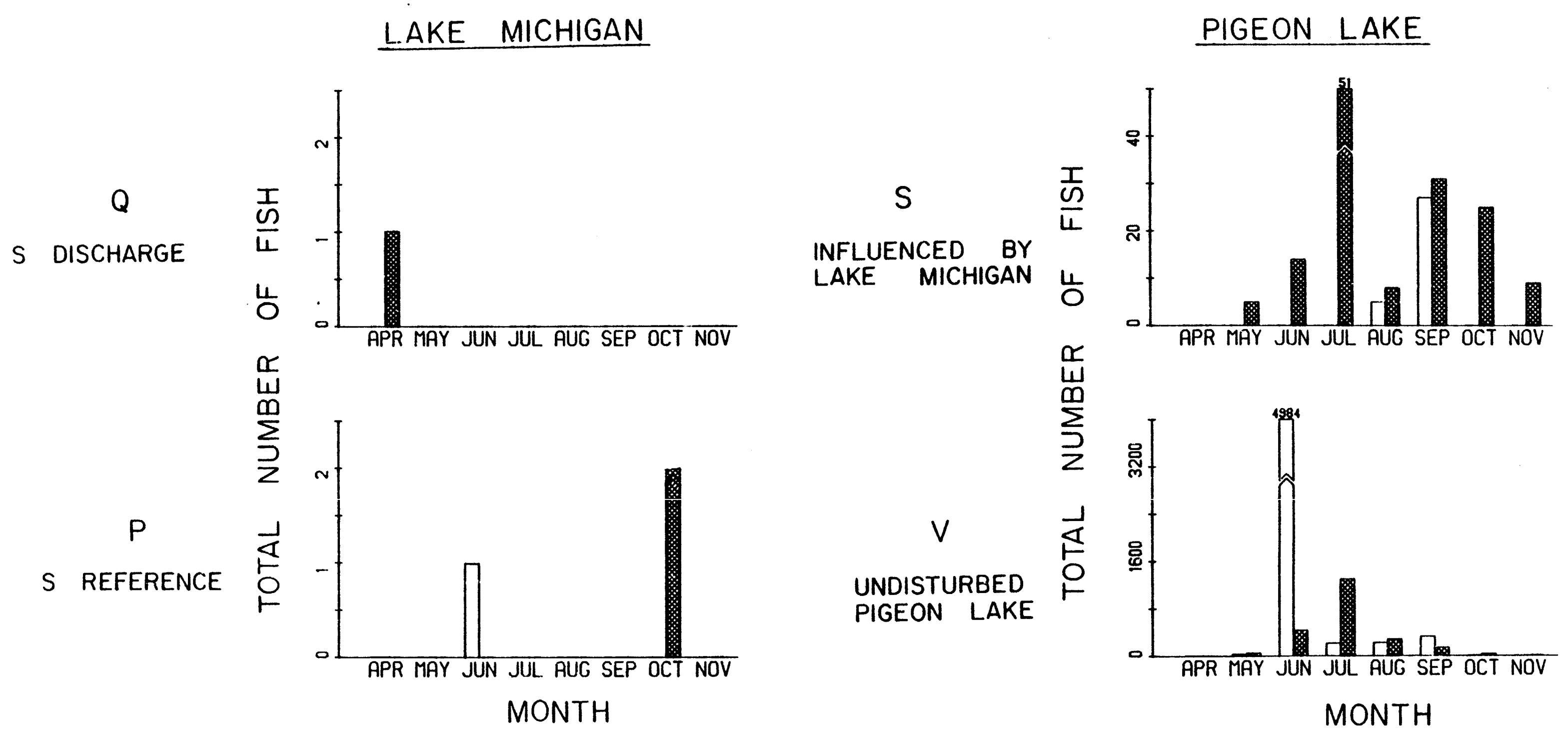


Fig. 35. Total number of yellow perch caught in duplicate seine hauls during day and night once per month April to November 1979 in Lake Michigan and Pigeon Lake near the J. H. Campbell Plant, eastern Lake Michigan. □ = day ■ = night.

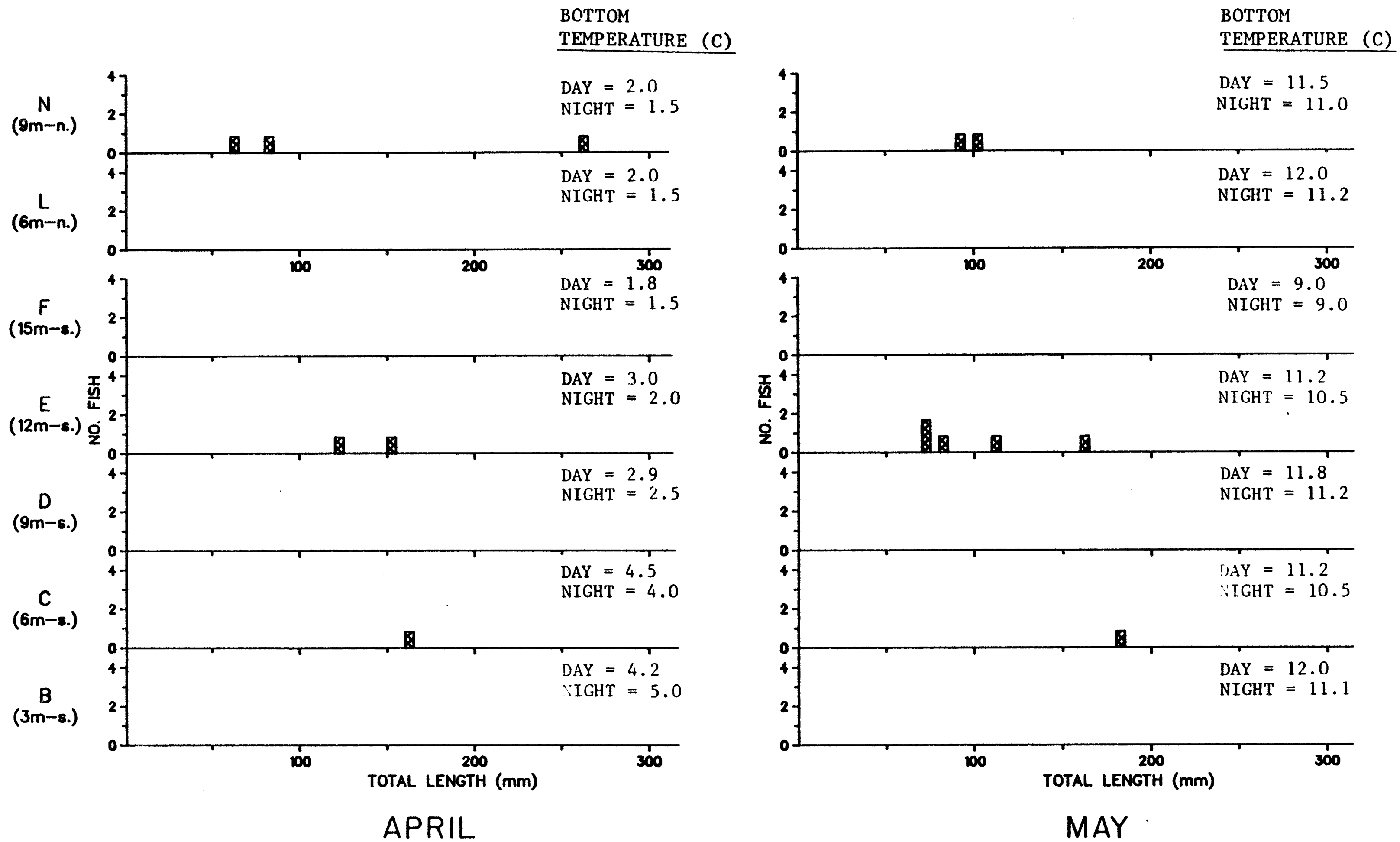
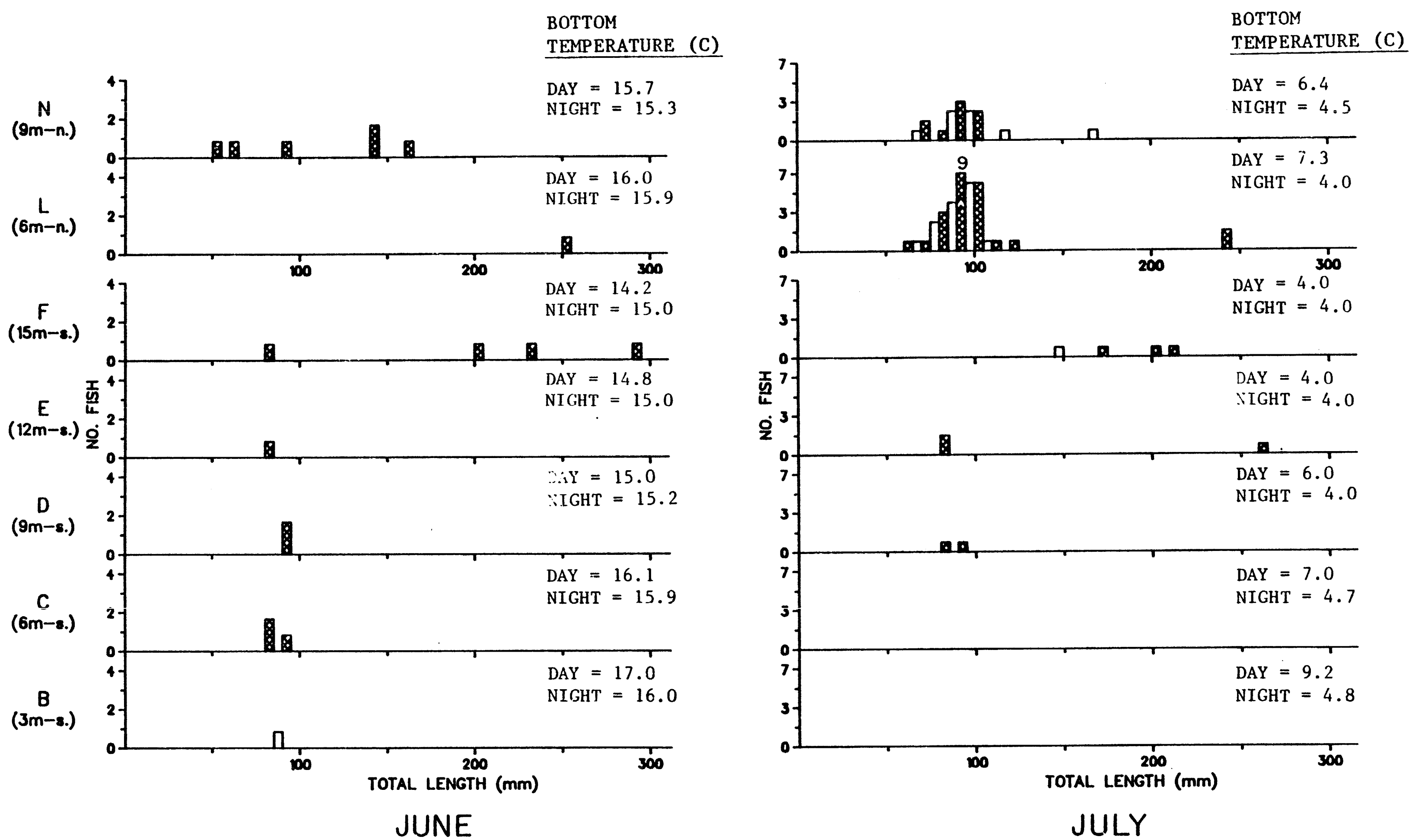


Fig. 36. Length-frequency histograms for yellow perch caught in duplicate trawl hauls during April to December 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan.
□ = day ■ = night * = no day sampling performed.



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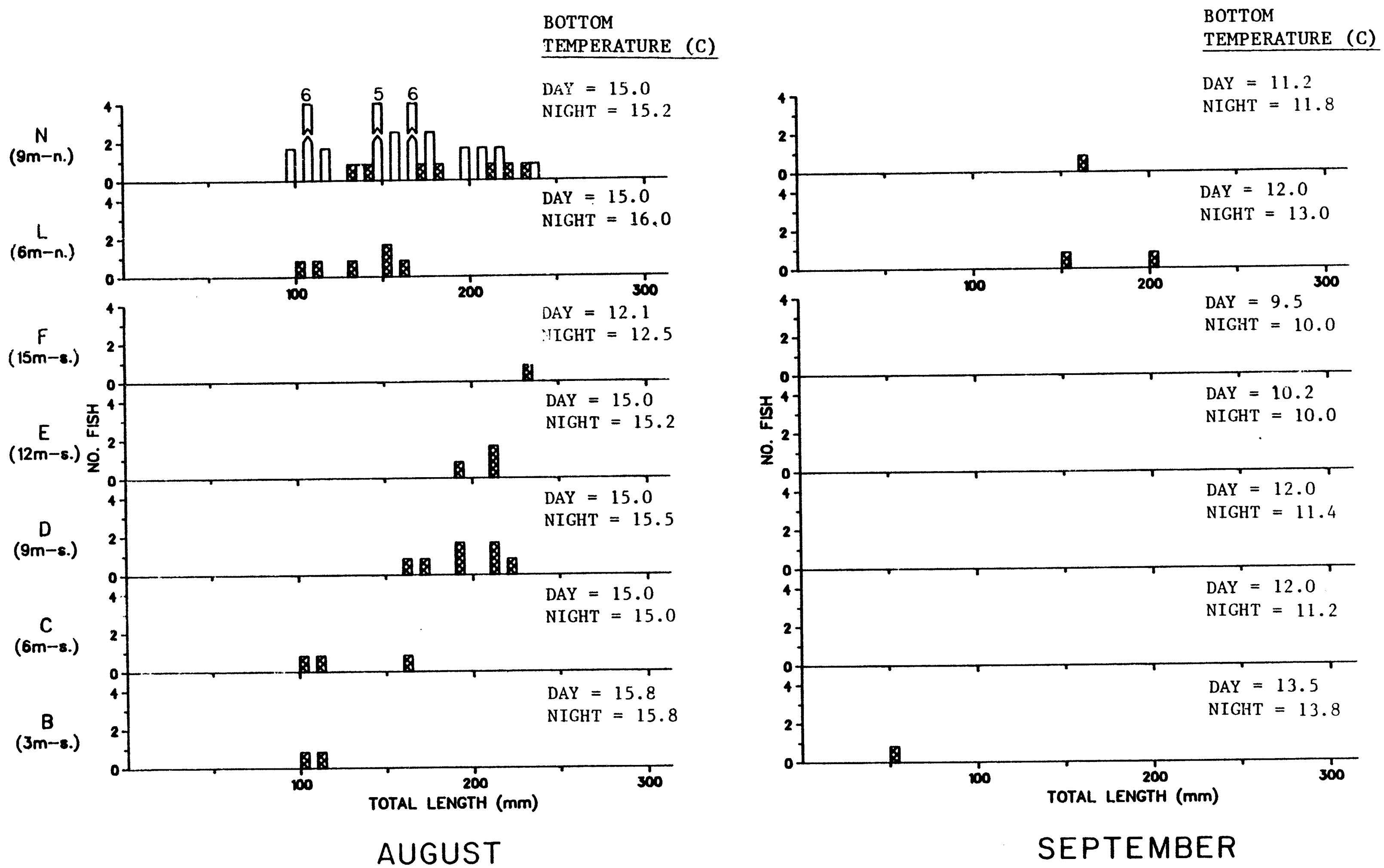

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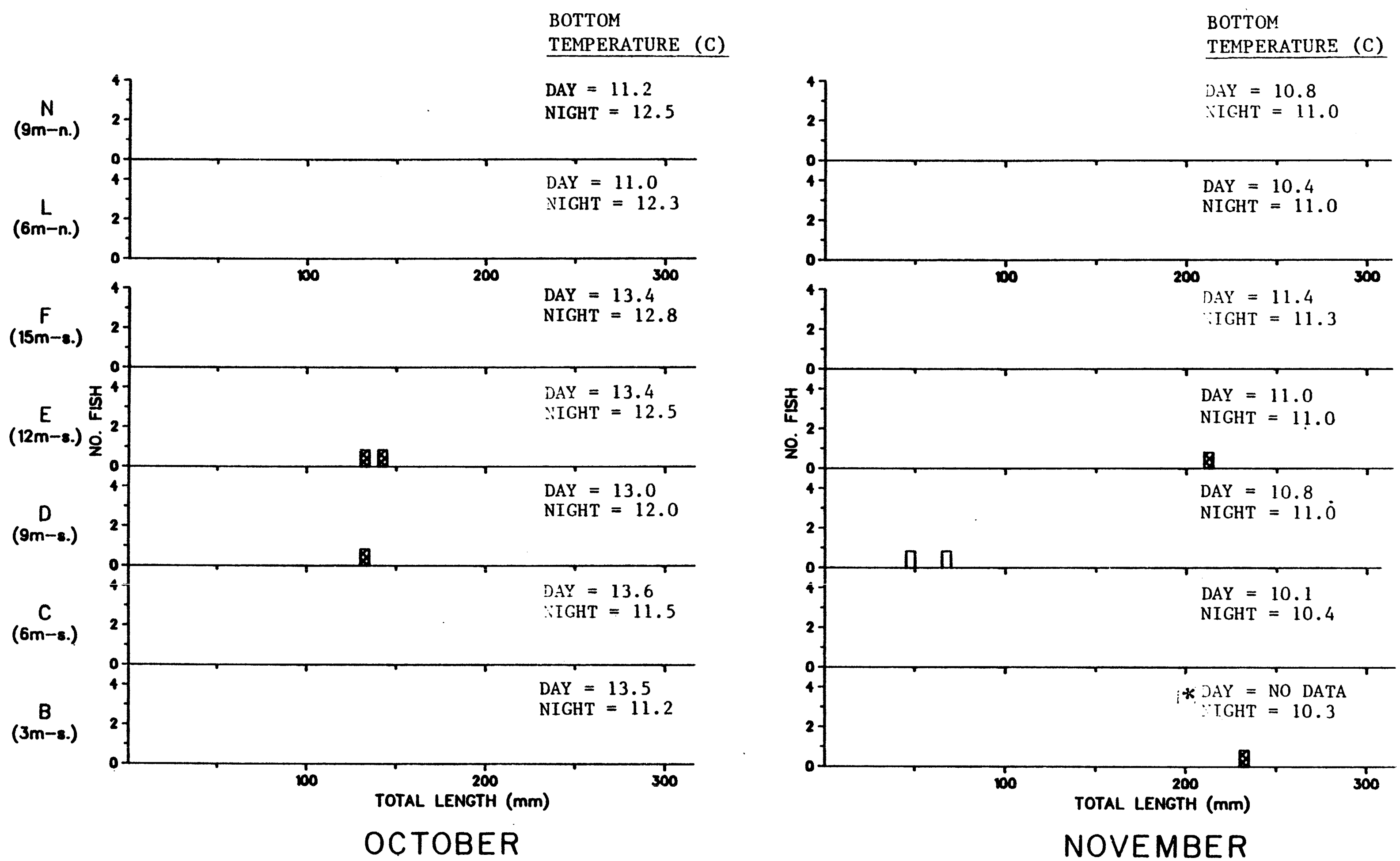

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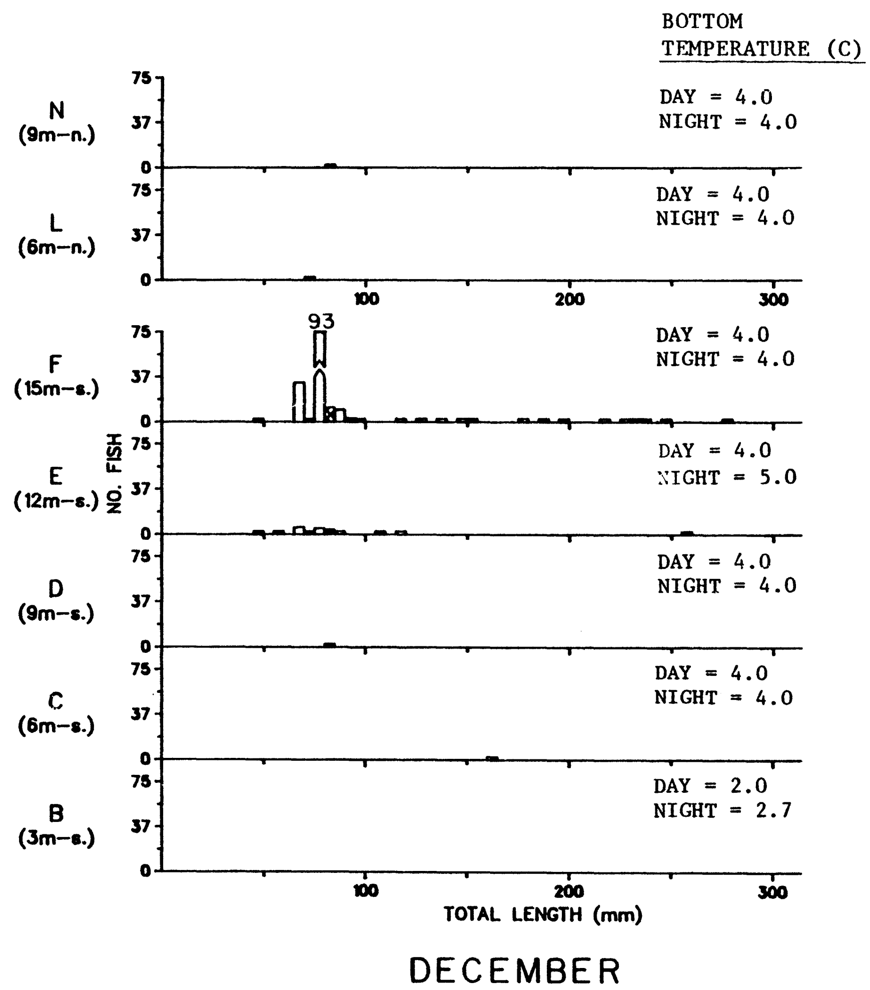

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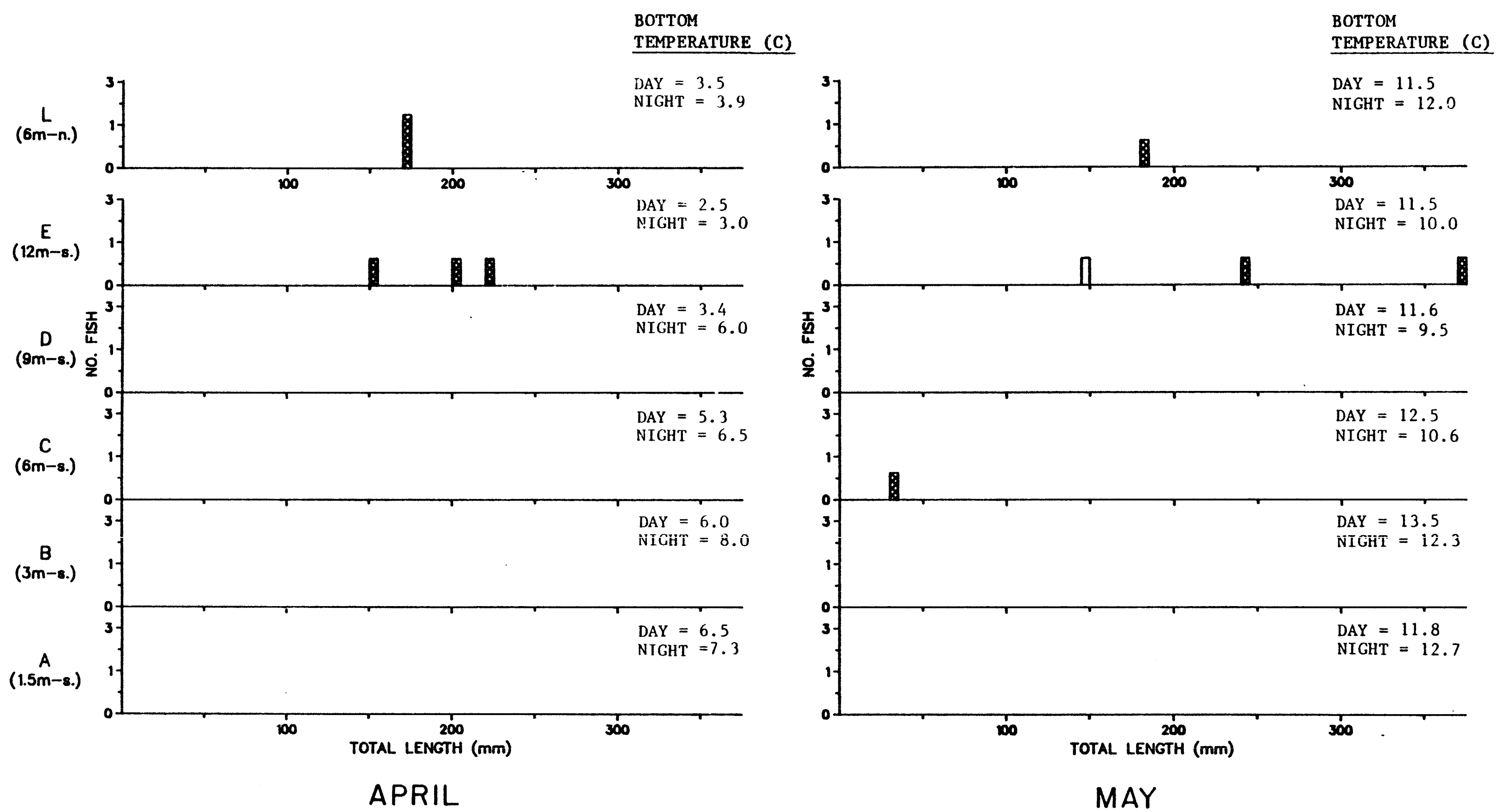
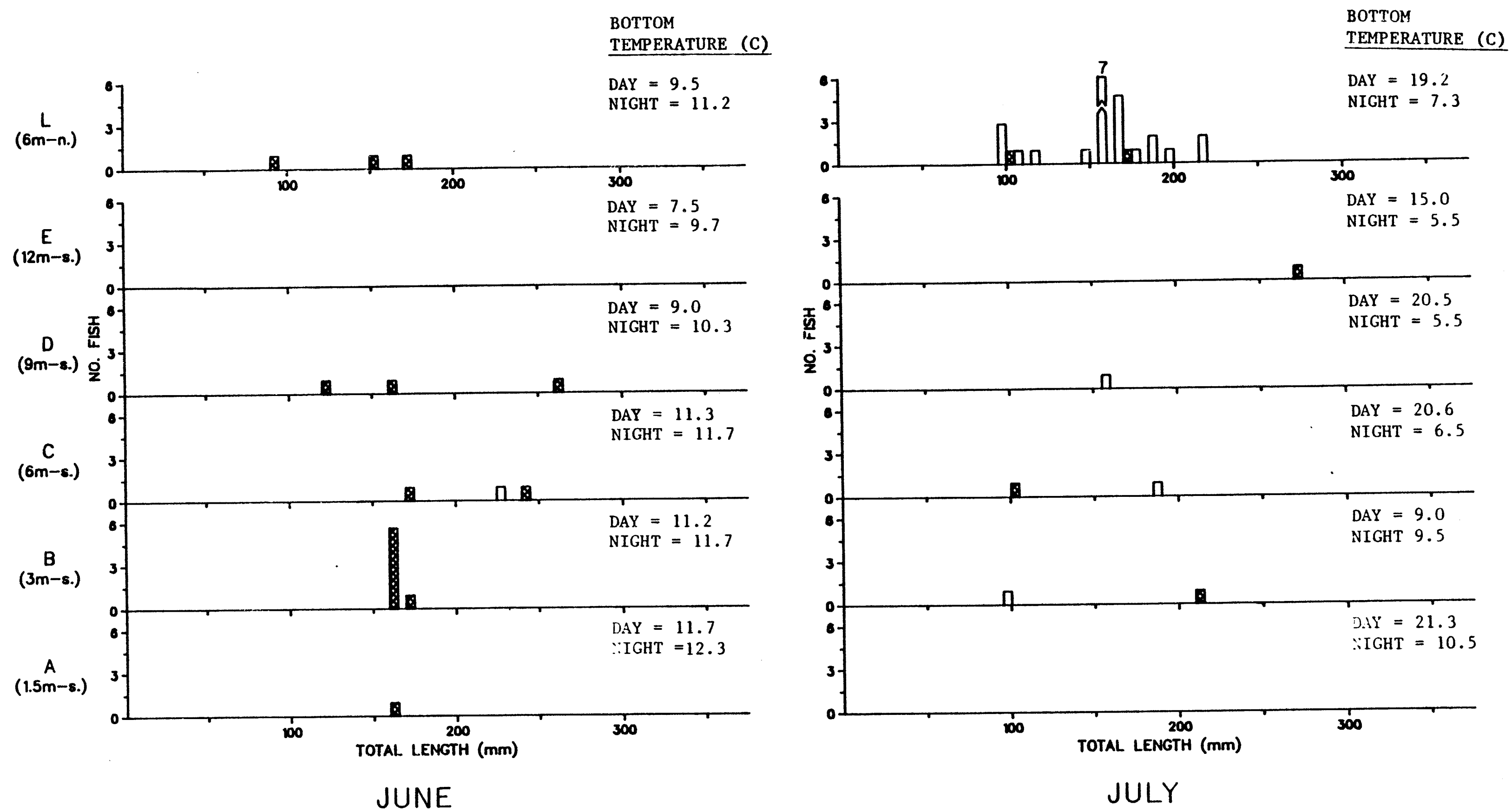


Fig. 37. Length-frequency histograms for yellow perch caught in duplicate bottom gill nets during April-November 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. □ = day ■ = night + = no sampling done.



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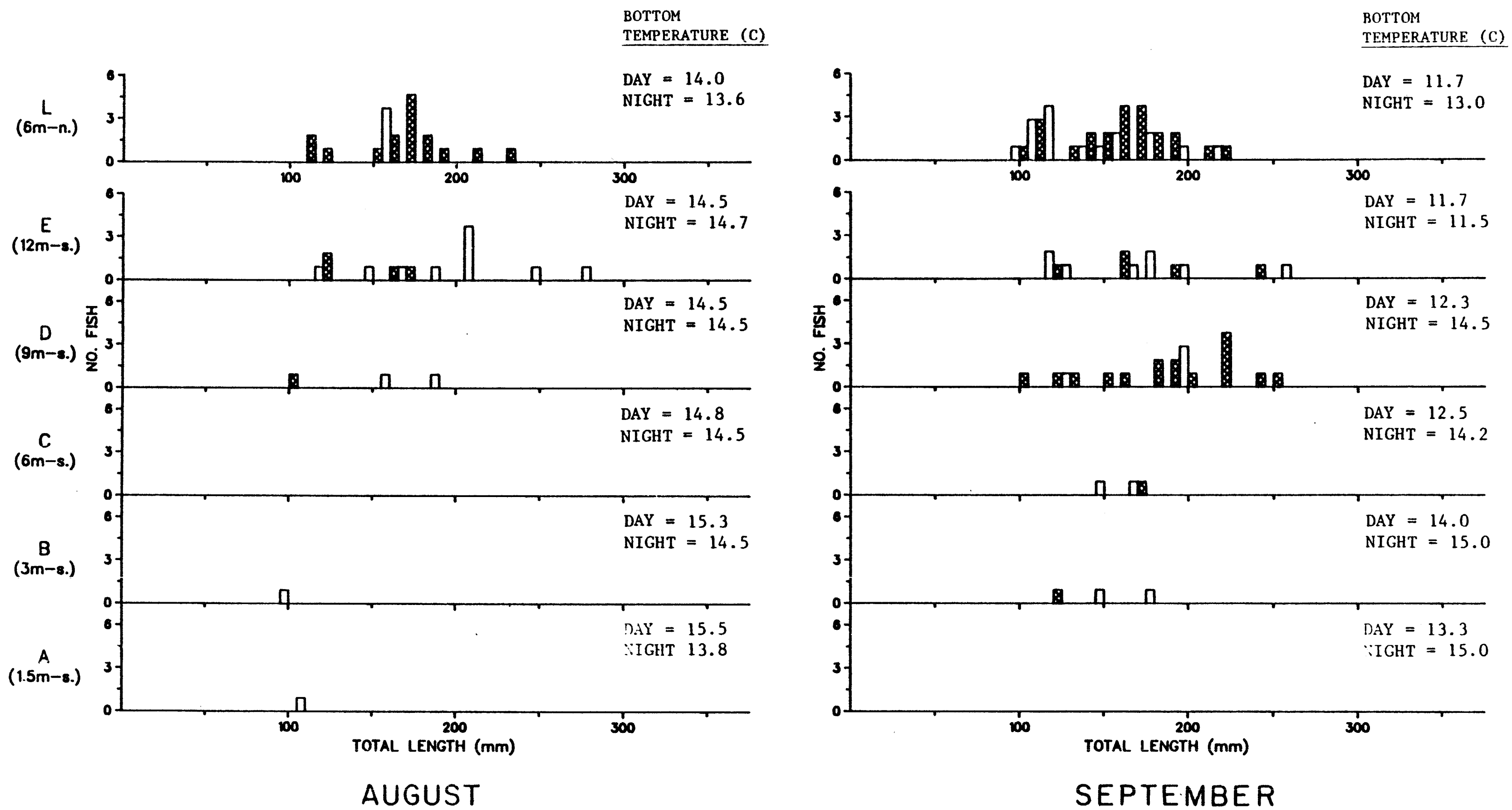

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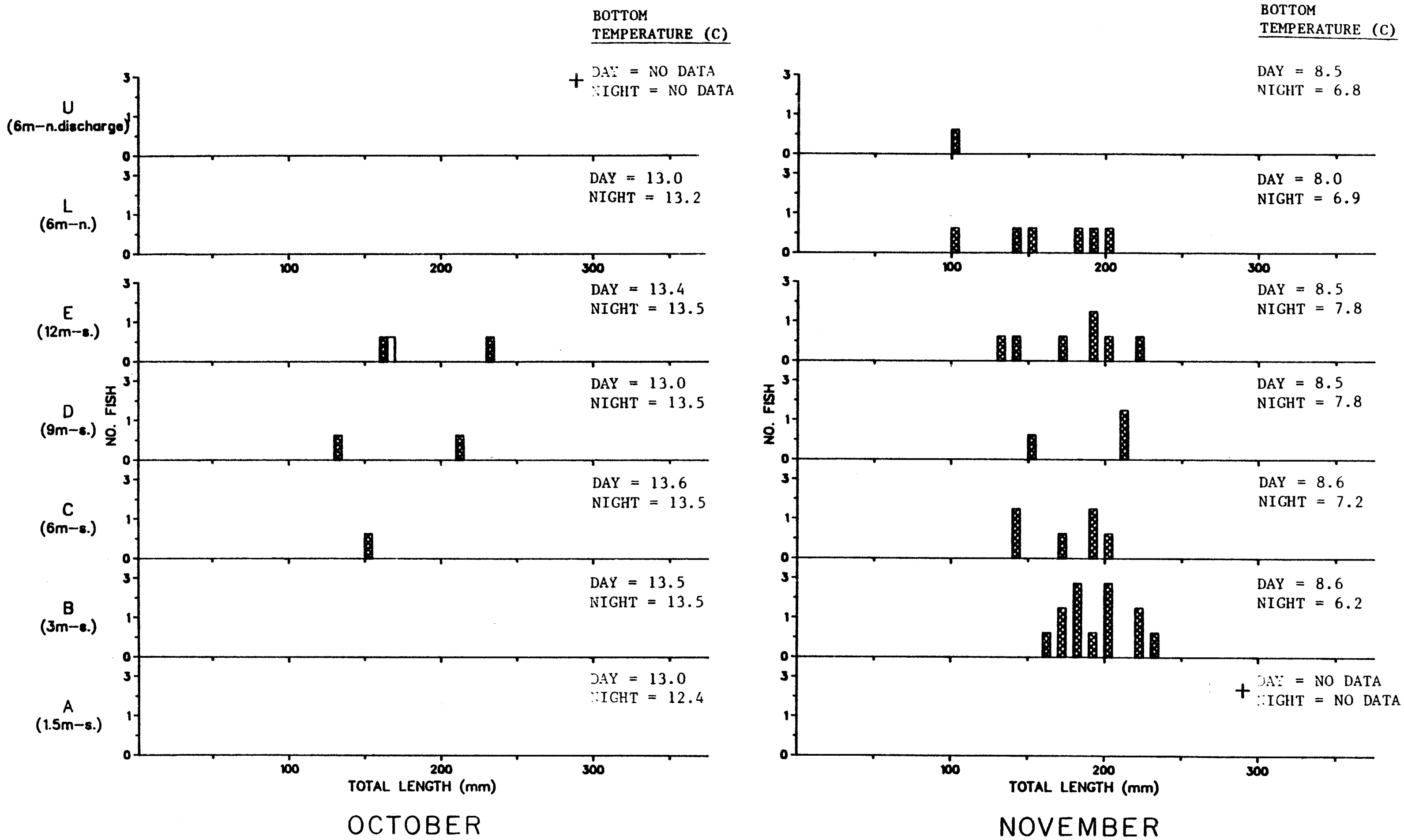


Fig. 37. Continued.

al. (1975) reported seasonal migration of yellow perch from deeper water (24 m) in early April to shallower zones (6-12 m) of eastern Lake Michigan when water temperatures reached 6-7 C on 21 May. Although water temperatures at Campbell Plant study areas warmed considerably from April to May 1979, sampling in May was completed by 15 May, and may have just missed the initial influx of yellow perch to shallower depths.

Gonad conditions were checked for 17 adult yellow perch in April and May. Most male fish were in moderate stages of sexual development, with only one male out of eight exhibiting well developed gonads. Female yellow perch were more advanced; of nine fish examined, six revealed well developed gonads. One female yellow perch taken in April was ripe-running. Spawning periods for yellow perch in Lake Michigan have been reported as mid-April to early May (Scott and Crossman 1973) and early May to early June (Van Oosten 1934). Our data indicate that yellow perch had not spawned by mid-May 1979.

June--Increasing catch of yellow perch at shallower depths (< 9 m) indicated a general inshore movement by mid-June. Few fish were taken at 12 m or deeper. However, as in April and May, most fish were distributed sporadically among stations in night trawl and gill net samples (Figs. 36 and 37). It appears that yellow perch may be retreating to deeper waters by day, at or beyond the 12-15-m depth zone. This observation is supported by sampling in two previous years (Jude et al. 1978, Jude et al. 1979a). Sampling in June 1977 revealed sizeable day catches of yellow perch in gill nets at station E (12 m, south) while fish caught at night in trawls were scattered at stations from 6 to 15 m. Few yellow perch were taken in June 1978 samples, but all were caught at night, scattered among stations from 12 m to the beach.

More than half of the adult yellow perch examined were still in early stages of gonad development in June (Table 24), but one spent male and two spent females were observed, indicating some spawning had occurred by mid-June in Lake Michigan. Gonad conditions noted in preceding years (Jude et al. 1978, Jude et al. 1979a) indicated considerably more spawning activity by mid-June than was apparent in 1979. Brazo et al. (1975) reported the first spent male yellow perch observed in 1972 in eastern Lake Michigan was taken in early June, but spent females were not observed until 26 June. He concluded that spawning in 1972 occurred from mid-May to the end of June. Similar spawning periods in 1973 and 1974 were reported for yellow perch in southeastern Lake Michigan near the D. C. Cook Plant (Jude et al. 1979b).

July--Large numbers of yellow perch at stations L and N (6-9 m, north discharge) dominated catch statistics for both trawls and gill nets (Fig. 34). Trawls captured predominately yearling fish (85-104 mm) with little difference noted between day and night sampling despite distinctly lower temperatures at night (Fig. 36). Gill nets, on the other hand, selected larger fish (most > 115 mm), almost all taken in day sets (Fig. 37). However, day gill nets were lifted more than 24 h before day trawls were completed, and over 30 h before night gill nets were set and night trawling performed. A strong upwelling over that period drove water temperatures from 19.2 C during day gillnetting to 7.3 C by the time night gill nets were set. Temperatures fell to 3.7 C during night trawling (about midway through the night gill net set). Yellow

Table 24. Monthly gonad conditions of yellow perch caught during 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. All fish examined in a month were included except poorly received specimens.

	Gonad condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Males	Slight development		2	5	16	49	44	4	1	5
	Mod. development	3	2	6	1	15	5	1	16	11
	Well developed	1				1			2	
	Ripe-running									
	Spent			1	2					
Females	Slight development		2	6	12	21	27	4	3	3
	Mod. development				1	2		1	12	3
	Well developed	4	2	2					4	
	Ripe-running	1								
	Spent			2	2					
	Absorbing									
Immature		3	5	13	63	9	9	1	2	73
Unable to distinguish				1	1		2			7

perch have been observed to move shoreward to avoid colder hypolimnetic waters during an internal seiche in Georgian Bay, Lake Huron (Emery 1970). Similar behavior during July sampling would have caused yellow perch to move inshore out of the range of discharge area sampling. Thus lack of older yellow perch in night gill nets may be a response to colder waters as well as a change in distribution due to diel periodicity.

In contrast to the presence of numerous yellow perch in samples at the north discharge area, trawls and gill nets at the south transect captured only a few individuals (Figs. 36 and 37). Catch differences cannot be attributed to differences in weather or water conditions, which were quite similar between the two sampling transects. A very similar fish catch distribution occurred in 1978. Only a few fish were taken at south transect stations, and fish of 85-104 mm were abundant at the north discharge area. However, in 1978, the bulk of the July catch occurred in seines at beach stations Q (south discharge) and R (north discharge), not at the 6-9-m stations (Jude et al. 1979a). Location of major catches in 1978 and 1979 corresponded with location of dredging operations which began close to shore in the discharge area in 1978 and proceeded out to 6-9 m by July 1979. Further evidence that dredging activity was influencing fish catch comes from sampling in July 1977, when there was no dredging activity in Campbell Plant study areas. Yellow perch catches were not concentrated at any single location, but appeared at

stations across all depths at both north and south sampling transects (Jude et al. 1978). Increased catch in the vicinity of dredging may be due in part to reduced water clarity as a result of suspended sediments, which would increase netting efficiency by reducing a fish's ability to detect nets. However, it is possible that increased catch represents a true increase in abundance of yellow perch near the dredging operations. Fish may have been attracted to the area as a result of greater availability of food, since disruption of bottom sediments by dredging would dislodge benthic organisms, suspending them in the water column where they are readily susceptible to predation.

Most adult yellow perch examined in July exhibited only slight gonad development, though a few were spent (Table 24). None of the yellow perch had well developed or ripe gonads, in contrast to previous months. Thus, it appears that most or all spawning in Lake Michigan was complete by the mid-July sampling period.

August--Distribution of catch among stations was very similar to that of July (Fig. 24). Although catch at station L (6 m, north) declined from July levels and more yellow perch were taken at south transect stations, most of the catch occurred again at north transect stations L and N (9 m). Trawl catches revealed a strong diel pattern; all 35 yellow perch occurring in day trawls were taken at station N (9 m, north), but 29 yellow perch taken in night trawls were scattered among all stations from 3 to 15 m.

September--Increased gill net catches combined with a sharp decrease in trawl catches resulted in only a slight overall change in total catch of yellow perch from August to September. Despite the shift in catch by gear, length-frequency distributions remained essentially the same (Figs. 36 and 37).

Both day and night gill net catches increased from August levels. Fish were still attracted to the discharge area, with exactly half the day catch and half the night catch occurring at station L (6 m, north). However, the rest of the yellow perch taken in gill nets were concentrated at stations D (9 m, north) and E (12 m, south) with only a few individuals present at shallower stations (Fig. 37).

In contrast to 64 yellow perch trawled in August, only 4 were taken in September trawls, all in night samples. Three older fish (> 145 mm) were captured at stations L and N (6-9 m, north). The fourth trawled yellow perch was the first YOY (about 50 mm) observed in Lake Michigan samples in 1979; it was taken inshore at station B (3 m, south). Trawling occurred 6 days later than gillnetting in September, and it is possible that in the interim yellow perch had moved from the sampling area to deeper waters. Migration of yellow perch to deeper waters of eastern and southeastern Lake Michigan in September was reported by Jude et al. (1979b) and Brazo et al. (1975).

October--Total catch in October was the lowest of any month in 1979 in which field sampling occurred. Trawl and seine catches remained at minimal levels, while gill net catches declined sharply from September levels (Figs. 34 and 35). Two YOY (55-74 mm) were taken in night seines at station P

(south reference), and nine older fish (125-234 mm) were taken in trawls and gill nets at depths of 6-12 m at the south transect. No yellow perch were captured in the discharge area.

November--Increased catch in night gill nets revealed yellow perch dispersed across all depths sampled (Fig. 37). Absence of fish in day gill nets indicated yellow perch were beyond the 15-m contour during daylight hours. Trawl catch remained low (four fish); two fish were YOY (45-74 mm) caught at station D (9 m, south) in day samples. Trawl sampling revealed very few fish at water temperatures of 10.1-11.4 C, while gill nets set 10 days later caught more yellow perch in waters of 6.2-8.6 C. Thus, it appears that presence of yellow perch inshore was not in response to warmer temperatures.

December--No seines or gill nets were set in December, but trawls alone produced the largest Lake Michigan catches of any month of 1979, almost twice the catch of the next most productive months (July and August). Exactly 200 yellow perch were caught, and 178 of these were YOY (45-104 mm). Most yellow perch (153 fish) occurred in day trawls at station F (15 m, south). Catches were moderate at station E (12 m, south) and only one or two individuals were caught at each of the 6-9-m stations, both plant-influenced and reference areas (Fig. 36). Thus yellow perch were distinctly concentrated at 15 m, with fish also present at 12 m and more rarely at 6-9 m. Water temperatures in the 6-15-m zone were consistently 4.0-5.0 C.

In December 1978, trawl catches were also dominated by YOY (55-104 mm) caught during the day at station F, with moderate catches at station E (Jude et al. 1979a). Bottom water temperatures were also low at this time, ranging from 2.0 to 3.5 C at 12-15 m. Other stations were colder (1.0-2.0 C). December 1977 trawls were also dominated by YOY (35-94 mm). Largest day catch occurred at station E (12 m, south), but most fish were taken at night at shallower stations B to E (3-12 m, south), with largest catch at station D (9 m, south). Temperatures ranged from 0.0 to 1.0 C (Jude et al. 1978).

Thus, over 3 yr of sampling in December, young yellow perch remained relatively concentrated at 12-15 m during the day. Samples in 1977 indicated fish were moving inshore at night. Despite cold water temperatures, it appears that young yellow perch remain in inshore waters through most of the winter.

<u>Seasonal Distribution - Pigeon Lake</u>--

April--Only four yellow perch were caught in Pigeon Lake, all females in the 140-mm length interval. Three fish were taken in day gill nets at 6-m station M; the other was captured in night seines at beach station V (undisturbed Pigeon Lake). This is in sharp contrast to April 1978, when Lake Michigan catches were very low (8 yellow perch), but Pigeon Lake revealed an abundance of yellow perch (126 fish); most were yearlings (55-114 mm) taken in seines at station V. Water temperatures were lower at beach stations S (influenced by Lake Michigan) and V in 1979 (6.6-8.5 C) than in 1978 (8.5-11.5 C) and sampling occurred earlier in the month in 1979 (April 17-18) than in 1978 (April 26). Thus, yellow perch were probably awaiting warmer

temperatures before inhabiting the beach zone. Water temperatures at 6-m station M in 1979 were almost identical to those of 1978 (7.0-7.4 C) when nine yellow perch were taken in day gill nets. Due to conflict with construction vessels using Pigeon Lake as a safe harbor, only day gill nets were set in April and no further gillnetting was performed in Pigeon Lake in 1979.

Examination for sexual condition of fish revealed one spent female and two with well developed gonads (Table 25). Spent fish were also observed in April 1978, yielding evidence of spawning in early April in Pigeon Lake.

May--Sizeable increases in seine catches at beach station V, plus a few yellow perch seined at night at station S, signified a definite increase in yellow perch presence in beach areas of Pigeon Lake (Fig. 35). Fish were in two size intervals (Fig. 38), yearlings (70-90 mm) and older fish (120-160 mm), comparable to the length-frequency distribution of fish sampled in May 1978 (Jude et al. 1979a). Higher water temperatures at station V (14.7-14.9 C) than station S (12.6-13.0 C), in addition to shallower slope and more extensive vegetation, may attract greater numbers of yellow perch to station V. Much higher day catches in May 1978 were associated with higher temperatures at stations V and S (15.3-17.0 C). Gonad conditions indicated most to all spawning in Pigeon Lake was complete. Only one spent female was observed out of 56 adults examined; all other yellow perch were in early stages of gonad development (Table 25).

June--Seine catches provided evidence of an exceptionally strong 1979 year class of yellow perch, compared to the 1977 and 1978 year classes. Two day seines at station V caught more yellow perch (4984 fish) than all previous sampling (all gear) for adults in Pigeon Lake in 1977 and 1978 together (4230 fish). Over 98% of these fish (4901) were YOY in the 20-30 mm length intervals (Fig. 38). This strong year class was first observed as an abundance of yellow perch larvae appearing in May net samples at beach station V (see FISH LARVAE AND FISH EGGS - Yellow Perch). Spawning success in Pigeon Lake may be correlated with physical conditions at station V (shallow slope and abundant vegetation) and appropriate water temperatures (see Temperature-catch relationships and Appendix 2). In addition Pigeon Lake is more sheltered from weather effects than Lake Michigan. Adverse weather has been documented as a destructive factor in yellow perch spawning areas on a large lake (Clady 1976).

Day seines at station V also accounted for 88 yellow perch longer than 75 mm. Night seining produced only 8% of the catch of day seines, with the same length groups represented. At station S (Lake Michigan influenced) only 14 yellow perch (all ≥ 75 mm) were taken, all in night seines (Fig. 35). The 20-30-mm size group was also noticeable in June 1977 samples, when 82 fish were seined in Pigeon Lake (Jude et al. 1978). However, in all of 1978, only seven yellow perch between 15 and 54 mm were captured, four in July day seines and three in night seines in September, October and November (Jude et al. 1979a).

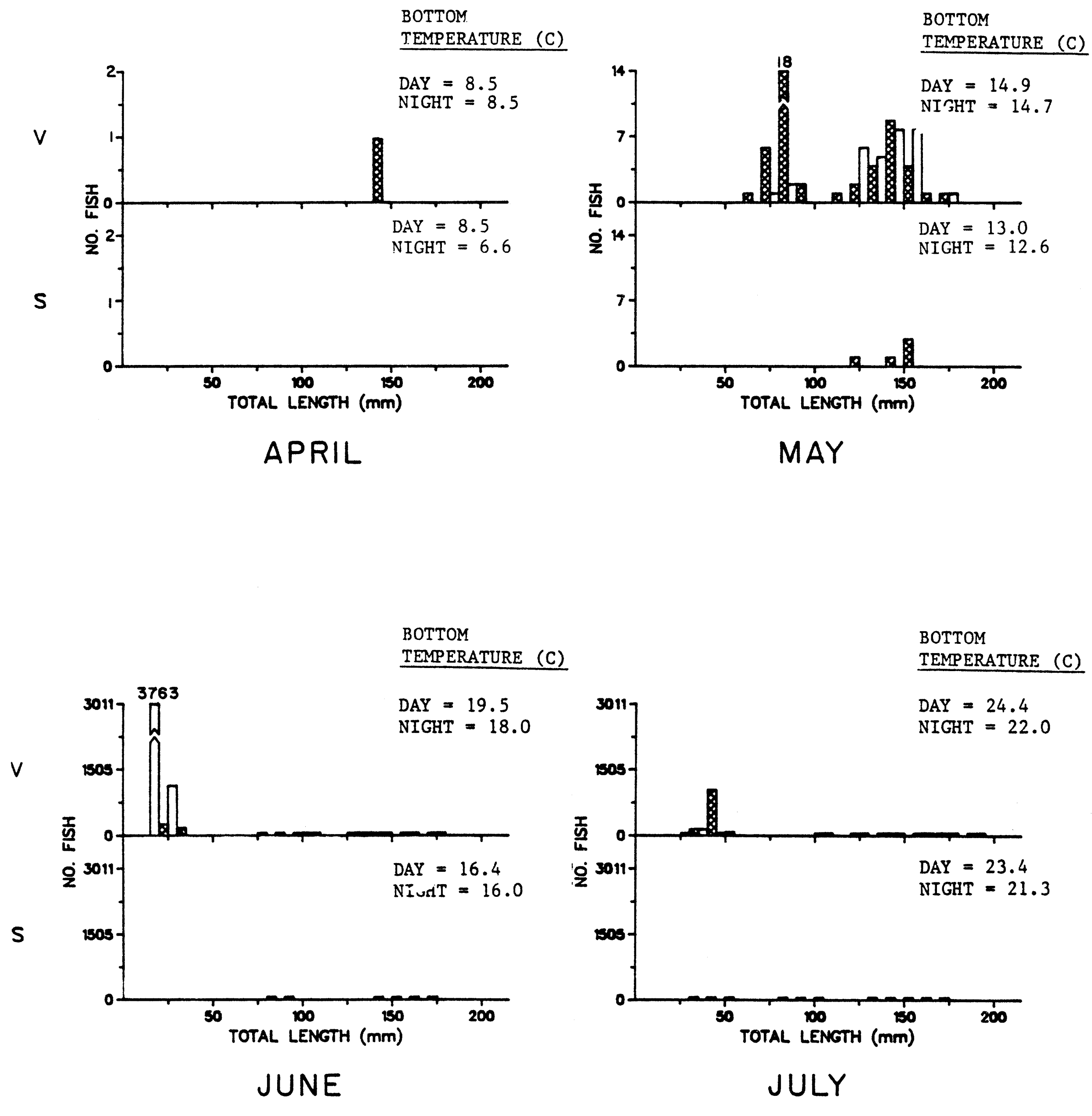


Fig. 38. Length-frequency histograms for yellow perch caught in duplicate seine hauls during April to November 1979 in Pigeon Lake near the J. H. Campbell Plant, eastern Lake Michigan. □ = day ■ = night.

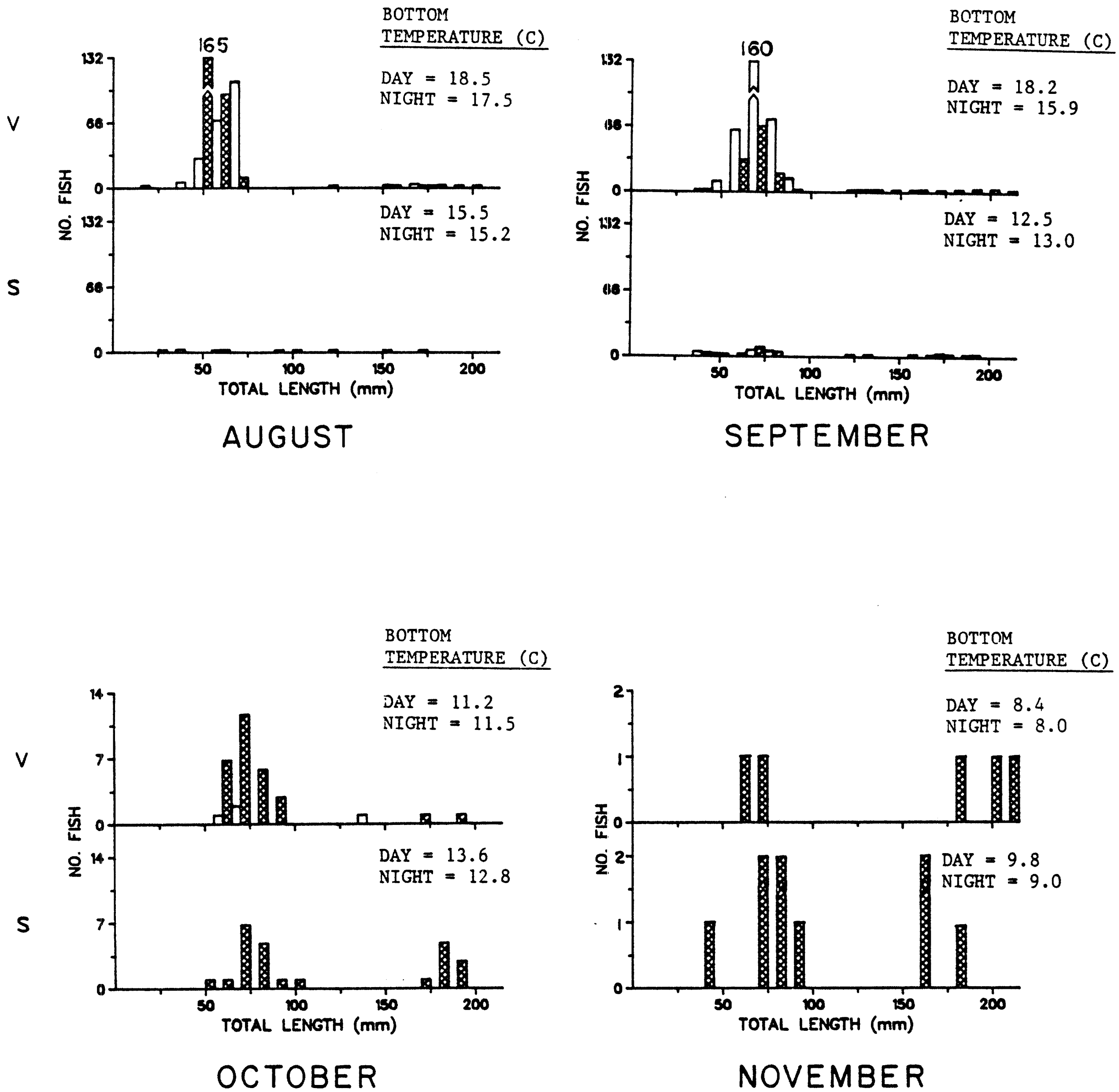


Fig. 38. Continued.

Table 25. Monthly gonad conditions of yellow perch caught during 1979 in Pigeon Lake near the J. H. Campbell Plant, eastern Lake Michigan. All fish examined in a month were included except poorly received specimens.

	Gonad condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Males	Slight development		20	26	14	13	2	6	6	
	Mod. development		19	10	16		6	2	1	
	Well developed									
	Ripe-running									
	Spent			1						
Females	Slight development	1	15	18	32	13	20	6		
	Mod. development		1	3			8	7	1	
	Well developed	2						2	3	
	Ripe-running									
	Spent	1	1							
	Absorbing									
Immature			29	181	107	95	150	24	3	
Unable to distinguish				8	3	3		12		

July--Large catches (1479 fish) of YOY (25-54 mm) at beach station V continued into July, although this was a decline from peak numbers in June (Fig. 38). In contrast to June, night catches predominated. Three YOY were taken at station S, possibly transported there from nursery areas near station V. Older fish (≥ 275 mm) were much more common at station S in July (48 yellow perch) than in June (14 yellow perch). Older fish were also present at station V in both day and night samples. Water temperatures were very warm at both stations V (22.0-24.4 C) and S (21.3-23.4 C).

In July 1977, YOY catch was not as numerous, but individual fish were larger (35-74 mm). Most YOY were caught at beach station T (influenced by Pigeon River), a station which was not sampled in 1978 or 1979. In 1978 only four YOY (25-54 mm) were taken in July in Pigeon Lake, all in day seines at beach station V.

August--YOY were still dominant in catches, but declining in abundance from July levels (Fig. 38). Most fish were again seined at station V, with day and night catches of comparable size. Length range of captured perch was wider (15-74 mm). Seven YOY were taken at beach station S, reflecting continued dispersal of young fish from nursery areas of the lake. Abundance

of older fish (≥ 75 mm) declined at both beach stations, indicating migration of these fish from the beach zone, although water temperatures were still 15.0 C or greater.

September--Catches in Pigeon Lake remained about the same as in August. YOY were the dominant size group, ranging from 35 to 94 mm, with other individuals reaching the 210-mm length interval (Fig. 38). Largest catches occurred at station V, especially in day seines. However, catch at station S increased over August levels, with a noticeably higher catch of YOY (44 fish, 35-84 mm) indicating increasing dispersal of young fish. Temperatures were still warm at station V (15.9-18.2 C), but showed a decline at station S (12.5-13.0 C).

October--A sharp drop in sampling temperatures at station V (11.2-11.5 C) accompanied drastically reduced seine catches at both Pigeon Lake stations (Fig. 35). YOY (45-104 mm) were still the dominant size group, with only a few older yellow perch (135-194 mm) observed at stations S and V (Fig. 38). Catch at station V was only slightly larger than at station S, indicating a more homogeneous distribution of fish at Pigeon Lake beach stations than in previous months.

November--Continued decline in catch reflected departure of yellow perch from beach stations as water temperatures dropped below 10.0 C. Only 14 yellow perch were taken at beach stations S and V; eight of these were YOY (35-94 mm). All yellow perch were taken in night seines. Catch at station S slightly exceeded catch at station V for the first and only time in 1979, indicating that preference for station V was no longer a factor in yellow perch distribution in Pigeon Lake.

<u>Impingement</u>--Estimated yellow perch impingement for 1979 (see IMPINGEMENT) was 1439 fish (1.13% of estimated total number of fish impinged) and 48.08 kg (1.02% of estimated total weight of fish impinged). Values were very similar to those reported for 1978, when yellow perch made up 1.11% by number and 1.22% by weight of all fish impinged. Compared to 1978, 1979 impingement of yellow perch was 5% lower by number, but 12% higher by weight. Yellow perch occurred consistently, but in low numbers in impingement samples, and were present in 36 out of 56 samples, exceeding 10 fish per 24-h sample in only 7 samples (January, March, April and November). Maximum catch in 24 h was 22 yellow perch on 5 March 1979.

Monthly estimated totals were highest (> 250 fish) in January, March and April, with large numbers (> 100 yellow perch) taken in November and December, and moderate numbers (80-100 fish) impinged in February and May. Estimated impingement was low (≤ 35 fish) in all other months. Thus yellow perch were impinged at highest rates through winter and spring months (November-May) and lowest rates in summer and fall (June-October).

Length-frequencies of impinged yellow perch revealed that, despite extremely heavy catches of YOY in Pigeon Lake field samples, impingement of YOY was minor. Peak months of YOY abundance in Pigeon Lake were June-September, but these were months of lowest yellow perch impingement. None of

the yellow perch impinged June-September were smaller than 145 mm. In October and November field samples, YOY ranged from 35 to 104 mm. In impingement samples two YOY were captured in October (the only yellow perch taken that month) yielding an estimate of nine YOY impinged for the entire month. Increasing numbers of YOY were taken in impingement samples in November (nine fish) and December (seven fish). During January, impingement of young yellow perch continued at a higher rate (25 fish) comprising more than 50% of all sizes of yellow perch impinged that month. February showed a similar high rate of impingement of young yellow perch, although actual numbers of fish impinged declined (8 YOY out of 14 yellow perch impinged). Only two YOY were impinged each month March through May. Thus despite extreme abundance in Pigeon Lake, YOY were not subjected to serious rates of impingement. YOY made up a significant proportion of monthly yellow perch catch only in winter months (November-February). Occurrence of young yellow perch in winter impingement samples at the Campbell Plant parallels observations at two other power plants on eastern and southeastern Lake Michigan (Consumers Power Company 1973a, 1973b; Jude et al. 1979b), providing strong evidence that young fish were remaining in inshore waters of Lake Michigan and Pigeon Lake through the winter.

No diel patterns were evident from impingement sample data. Day and night catches were often almost equal. Totalled over all samples in 1979, 57 yellow perch were taken in day samples while 59 were impinged at night. Samples taken at dusk and at dawn revealed similar values (52 fish and 32 fish respectively). Thus diel patterns of yellow perch abundance and behavior were not affecting their susceptibility to impingement.

Examination of gonads of impinged fish revealed a few ripe-running yellow perch in March and May. Only one spent yellow perch was taken, which occurred in a June sample. Impinged fish exhibited characteristics of sexual condition similar to both Lake Michigan and Pigeon Lake field-sampled fish.

Overall, the pattern of yellow perch impingement indicates a "chance" selection of fish from both Lake Michigan and Pigeon Lake waters. The notable exception was the ability of abundant YOY yellow perch at Pigeon Lake beach station V to avoid impingement in summer months. Greatest impingement of yellow perch occurred in winter months, but lack of field samples from January to March precludes assignment of these fish to either Lake Michigan or Pigeon Lake.

Yellow perch was the second-most abundant species of larvae entrained during both 1978 and 1979. Projected totals for those 2 yr reached 16,435,800 and 14,571,200 larvae respectively. Most of these larvae were entrained during May and June and probably originated from Pigeon Lake spawnings. Late summer catches of YOY yellow perch in adult sampling gear were extremely high at Pigeon Lake stations in 1979 indicating that although the plant entrained many yellow perch larvae over the past 2 yr, perch populations in the area were not severely diminished.

<u>Temperature-catch relationships</u>--Despite observations by McCauley and Read (1973) that temperature selection of yellow perch was influenced by age of fish, water temperatures at time of capture were not well correlated with size of yellow perch taken in our field samples. It is likely that temperature-length relationships were obscured by factors such as gear bias, seasonal and diel shifts in fish abundance and water temperatures, and special influences such as spawning location preferences and dredging operations. Laboratory determinations indicate that mature yellow perch require several months of cold temperatures (4-10 C) for successful gonad development (Jones et al. 1977). Both Pigeon Lake and Lake Michigan meet this requirement. Scott and Crossman (1973) suggest that yellow perch follow the 20 C isotherm during seasonal and vertical movements. During 1979 sampling, temperatures exceeded 20 C only during July at Pigeon Lake stations S and V and during July day gill net sets at inshore stations A, C and D (1.5-9 m, south). McCauley (1977) reported seasonal variation in temperature preference of yellow perch and concluded that temperature preferences and temperature gradients in nature served to guide yellow perch to areas suitable for spawning in spring and conducive to growth during summer.

Suitable spawning temperatures (8.9-12.2 C, Scott and Crossman 1973) occurred at beach station V in Pigeon Lake in mid-April. Temperatures at station S and at Lake Michigan beach stations were similar, but more variable (6.6-10.5 C). Station V was consistently warmer from May through September than either station S or Lake Michigan beach stations, and it is likely that YOY yellow perch remaining at that area through the summer benefited from temperatures more conducive to growth than at other areas (McCormick 1976).

<u>Growth and development</u>--Scales were examined from 36 yellow perch taken from Pigeon Lake and 124 perch taken from Lake Michigan in November 1979. Back calculations of total length at age for each fish were performed using the Dahl-Lea method (Lagler 1956). Confidence intervals (= 0.05) for mean length at age were calculated separately for male, female and unsexed fish for each lake. Comparisons of confidence intervals indicated no statistically significant differences in mean length at age among the six groups at ages 1, 2 and 3. Confidence intervals for perch from each lake were recalculated with male, female and unsexed fish combined (Fig. 39). There were no significant differences in mean length at age between Lake Michigan and Pigeon Lake perch. However, the overlap of age-1 confidence intervals was very small, and at age 3 the confidence interval of Pigeon Lake perch was excessively large. Estimates of mean length at ages 1 and 3 would be improved by larger samples of fish and might enable detection of real differences between Pigeon Lake and Lake Michigan perch.

Despite the lack of significant differences in mean length at age, there were apparent differences in age distribution of fish taken from the two lakes, assuming that bias and efficiency of sampling gear were comparable in both lakes. Only 3 of 36 perch (8.3%) taken in Pigeon Lake were as old as age 3; whereas, 32 of 124 Lake Michigan perch (25.8%) exceeded age 3, with 1 fish attaining age 8 (Fig. 40). Lack of older perch in Pigeon Lake samples may be

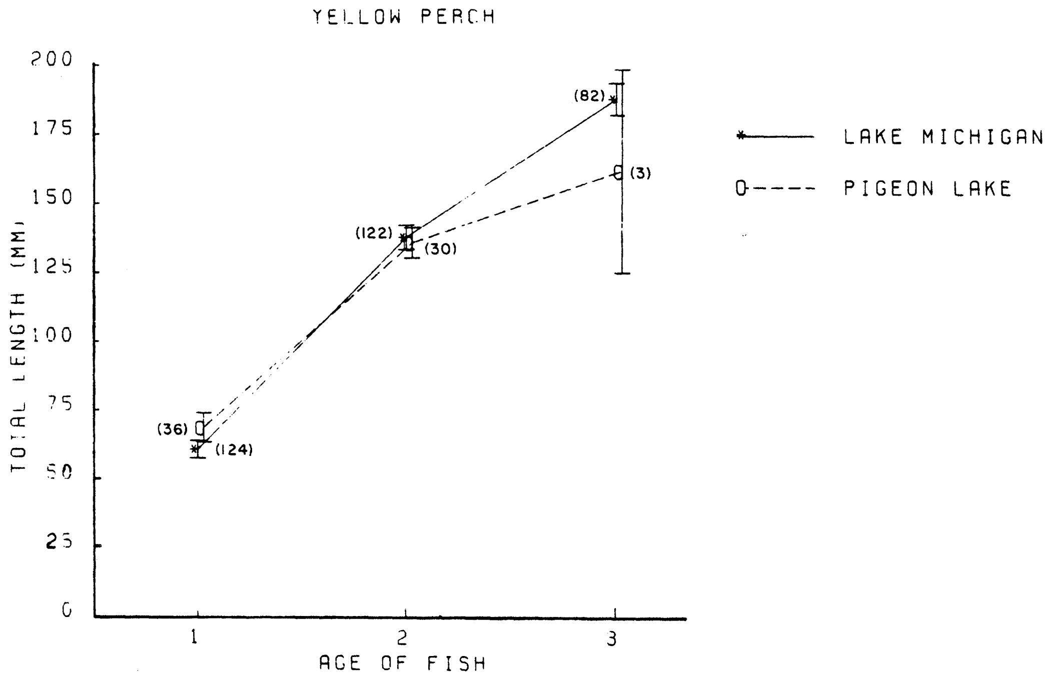


Fig. 39. Total length as a function of age back-calculated for yellow perch collected from Lake Michigan and Pigeon Lake, November 1979. Vertical bars represent 95% (α = 0.05) confidence limits about mean total length for male, female and unsexed perch combined. Sample sizes (N) are given in parentheses.

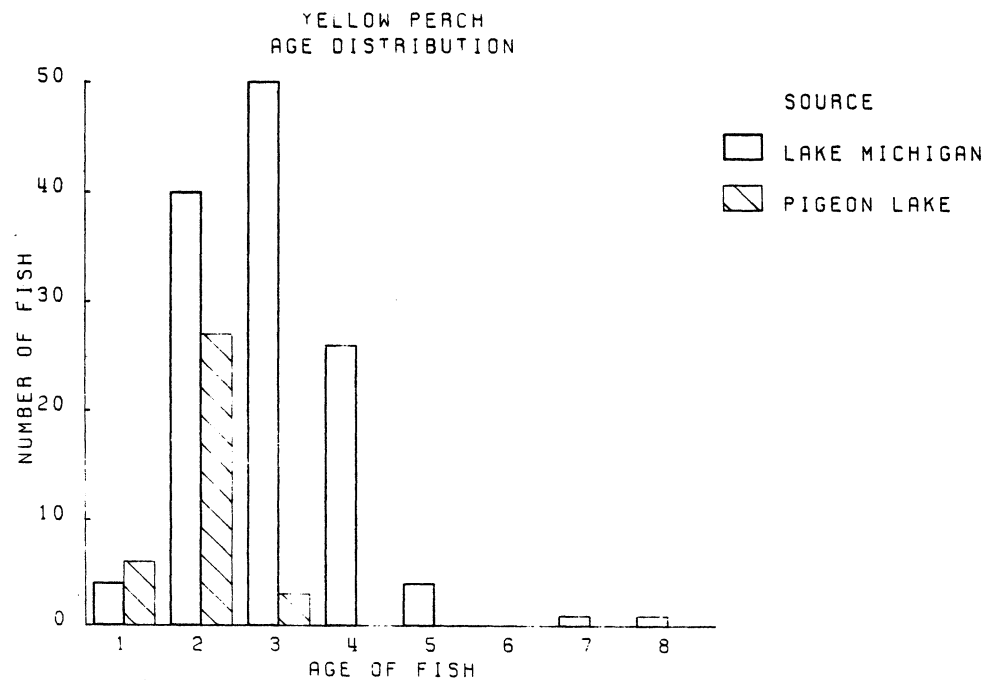


Fig. 40. Age-frequency histogram for yellow perch collected from Lake Michigan and Pigeon Lake, November 1979.

due to high mortality rates (fishing pressure). A survey of Pigeon Lake recreational users undertaken in early 1980 (Jude et al. 1980) indicated that over 8000 yellow perch were taken by sport fishermen in 1979.

Plant impacts--Data from 1979 impingement and field samples suggested Campbell Plant operation was having minimal impact on yellow perch populations in the study areas. Impingement total in 1979 (1439 fish) was very similar to 1978 levels, despite extreme increase in abundance of yellow perch in Pigeon Lake. Seasonal and diel patterns of fish abundance evident in field samples were not reflected in impingement, indicating that impingement was a random or chance event, not correlated with yellow perch abundance. Exceptional spawning success in Pigeon Lake revealed that stocks of mature yellow perch had not been depleted by plant operation through 1979. Persistence of YOY in Pigeon Lake through the summer indicated that plant operation was not seriously affecting survival and growth of young fish, and few YOY were found in impingement samples from summer through late fall.

Impingement of yellow perch increased through winter months, but lack of field samples January through March prevents assignment of impinged fish to either Lake Michigan or Pigeon Lake. However, estimated total impingement of yellow perch in all of 1979 does not appear to represent a significant loss of fish from either Lake Michigan or Pigeon Lake populations. Projected losses of yellow perch larvae due to entrainment totalled 16.2 and 14.6 million larvae for 1978 and 1979 respectively. Despite these losses, YOY yellow perch were remarkably abundant at Pigeon Lake stations in late summer 1979, indicating that the perch population was not seriously depleted by entrainment of larvae. One noticeable effect of Campbell Plant operation on yellow perch in 1979 was concentration of fish in the vicinity of dredging operations. No increase in mortality was noted, and it is possible that fish benefited from the dredging due to increased availability of food as dredging disrupted bottom sediments.

Summary--Yellow perch were abundant in Lake Michigan in Campbell Plant study areas. Diel patterns of behavior (schooling by day offshore and dispersal and inshore movement at night) were evident in trawl and gill net catch distributions. Seasonal changes were similar to those reported in many other studies in eastern and southeastern Lake Michigan. Yellow perch were scarce in shallower waters (≤ 15 m) in April and May, but moved inshore to depths ≤ 9 m by mid-June. Spawning in Lake Michigan was probably completed by the end of June. Sampling in July, August and September indicated fish may have been attracted to the 6-9-m area of the north transect, most likely due to disruption of food organisms from bottom sediments in that area by dredging. However increased catches at 6 and 9 m stations may have been due to reduced net avoidance, as dredging reduced water clarity. Fish abundance declined in October and November, as yellow perch moved back to deeper water (≥ 9 m), but large catches of YOY at 15 m in December indicated YOY yellow perch were inhabiting inshore waters.

Yellow perch were scarce in Pigeon Lake catches in April, but abundance increased as waters warmed in May. Gonad data, though sparse, indicated spawning occurred in April and early May. Lack of gill net data precluded

monitoring of deep water (7 m) abundance in Pigeon Lake. Seining at station V in June revealed exceptional spawning success for yellow perch in 1979 compared to 1977 and 1978, while few yellow perch were observed at the Lake Michigan-influenced station S. YOY persisted at station V through October, though abundance declined monthly. Increased appearance of YOY at station S from July through September indicated increasing dispersal of young fish from the spawning-nursery area at station V. Declining water temperatures in October and November accompanied reduced presence of yellow perch at beach stations, as fish retreated to deeper water.

Yellow perch were impinged consistently, but in small numbers throughout 1979. Months of lowest impingement (June-September) corresponded to periods of highest yellow perch abundance in Pigeon Lake, while exceptional abundance of YOY in Pigeon Lake was not reflected in impingement samples. Gonad conditions of impinged fish revealed characteristics of both Pigeon Lake and Lake Michigan yellow perch. YOY yellow perch were present in impingement samples through winter and early spring (November-May) indicating YOY yellow perch were remaining in inshore waters through the winter. Despite entrainment of large numbers of yellow perch larvae in 1978 and 1979, perch populations appeared to be unaffected, indicating that Campbell Plant operation has probably had minimal impact on yellow perch populations in the study areas.

Unidentified Coregoninae--

Introduction--Throughout the 3-yr preoperational study, a group of fish belonging to the genus *Coregonus* have been increasing in abundance in our catches. The difficulty in identifying these fish to species has been discussed by Jude et al. (1975, 1978 and 1979a). Most of these coregonines are believed to be bloater *Coregonus hoyi* or a hybrid thereof. These coregonines, often called "chubs", were fished commercially until the fishery was closed in 1976.

Seasonal distribution--Unidentified coregonines comprised 7% of the total number of fish collected from Lake Michigan during 1979. During 1978 these fish accounted for 3.4% of the total catch while in 1977 only 0.6%. From May to December 1979, 5713 unidentified coregonines were taken by seine (0.18%), surface gill net (0.12%), bottom gill net (3.97%) and trawl (95.73%). Five young coregonines were also collected by seine in Pigeon Lake (Appendix 7).

Similar trends were observed in 1978 (Jude et al. 1979a); however, no unidentified coregonines were collected from Pigeon Lake and fewer were recovered from bottom gill net sets. The catch in 1978 consisted mostly of individuals less than 160 mm; only seven fish exceeded this length. During 1979, 616 fish were greater than 160 mm. This group of fish may represent age-2+ individuals (Fig. 41) and account for the increased catch of unidentfdied coregonines in bottom gill nets particularly during July (Appendix 7).

April, May--As in 1978, a few coregonines were first captured in the study area during May. Eight were trawled at Lake Michigan stations E (12 m, south), F (15 m, south) and N (9 m, north). These fish averaged 78 mm (SE = 6.2, N = 8), and were probably age-1 individuals spawned during early 1978 (Fig. 41).

June--During June unidentified coregonines occurred in trawl, seine and bottom gill net catches in Lake Michigan and in seine samples from Pigeon Lake. In Lake Michigan four 75- to 104-mm fish were taken in a June seine at beach station R (north reference) during the day. Water temperature at time of capture was 15.8 C. Twenty-eight unidentified coregonines were collected in bottom gill net sets; all but one were collected at night (Fig. 42). These fish were captured at stations C (6 m, south), D (9 m, south), E (12 m, south) and L (6 m, south discharge) at water temperatures between 9.7 and 11.7 C; fish ranged in length from 115 to 214 mm.

The largest catch of unidentified coregonines in June occurred in trawls (277), 22 during the day and 255 at night. Coregonines were recovered from all stations trawled in Lake Michigan; most occurred at 9 to 15 m along the south transect and at 6 and 9 m on the north transect (Fig. 43). Water temperatures at time of trawling were warm, 15.2 to 15.9 C.

Four small coregonines (37-55 mm) were also collected by seine in 1979, however, these fish were unexpectedly recovered at Pigeon Lake station S (influenced by Lake Michigan). These young fish are probably YOY. They were taken in water 16.4 C during day seining.

The June catch in Lake Michigan consisted primarily of yearling coregonines (Appendix 6). Of the total 309 caught, 24 fish were greater than 160 mm. These were probably 2-yr-old and older fish averaging 178 mm (SE = 2.2). The remaining 285 fish averaged 100 mm (SE = 0.59) and were probably age-group-1 individuals (Fig. 41).

July--As was the case in 1978, the greatest catch of unidentified coregonines occurred during July. Caught mostly in trawls, 2,730 coregonines were sampled. A few fish were taken in bottom gill nets (183) and surprisingly some in surface gill nets (7) (Fig. 44).

During July unidentified coregonines were trawled at all stations, but catches were greater at the 6- and 9-m stations at the north transect and at the 3-, 6- and 9-m stations along the south transect. Water temperatures were very cool, well below usual for July (4.8 to 3.7 C) indicating an upwelling. Although temperature and Secchi disc readings were similar at both transects, the greatest catch (1,153 or 42%) occurred at north transect station L (6 m, south discharge) (Fig. 43).

For the first time in our sampling program, coregonines were recovered from surface gill net sets at each of the 6-m stations. These fish were all caught at night and ranged between 120 and 130 mm. Warmer water temperatures (8.5 to 10.0 C) than those observed during trawling were recorded during these

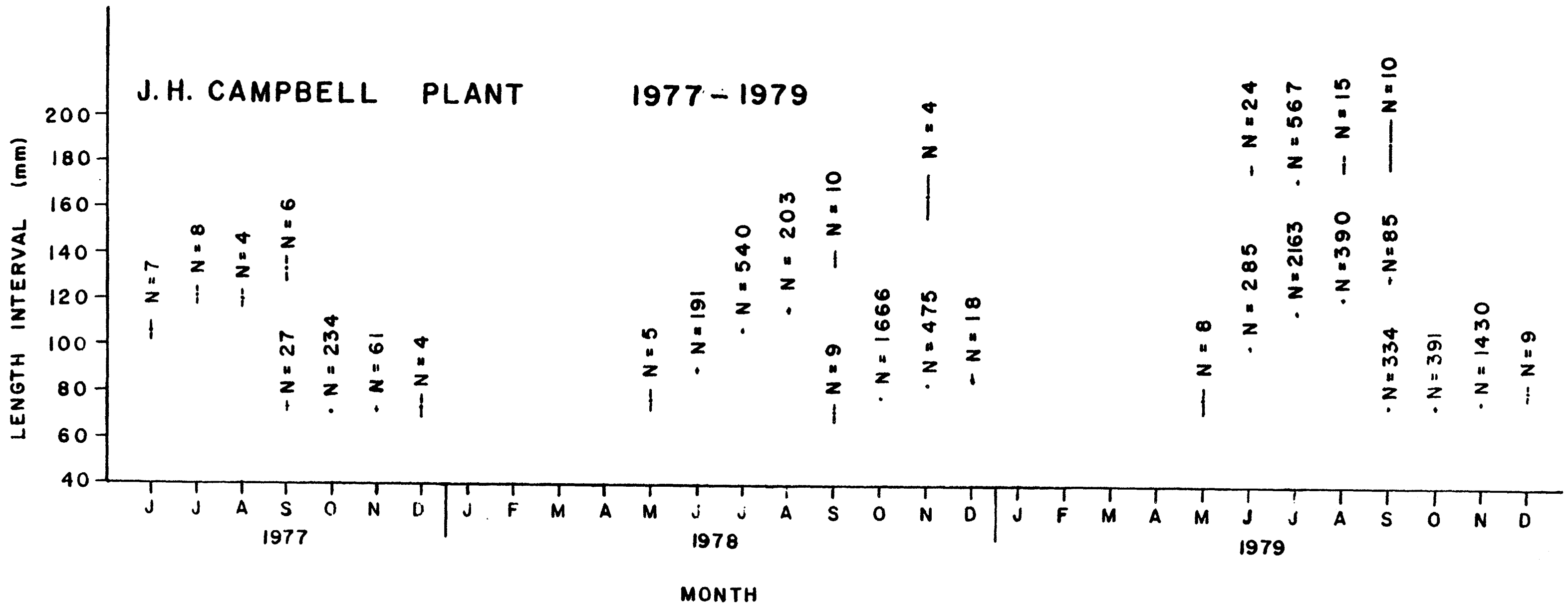


Fig. 41. Monthly average length of unidentified coregonines collected in all sampling gear in the vicinity of the J. H. Campbell Plant, eastern Lake Michigan, 1977 to 1979. Bar indicates standard error, N = number of observations.

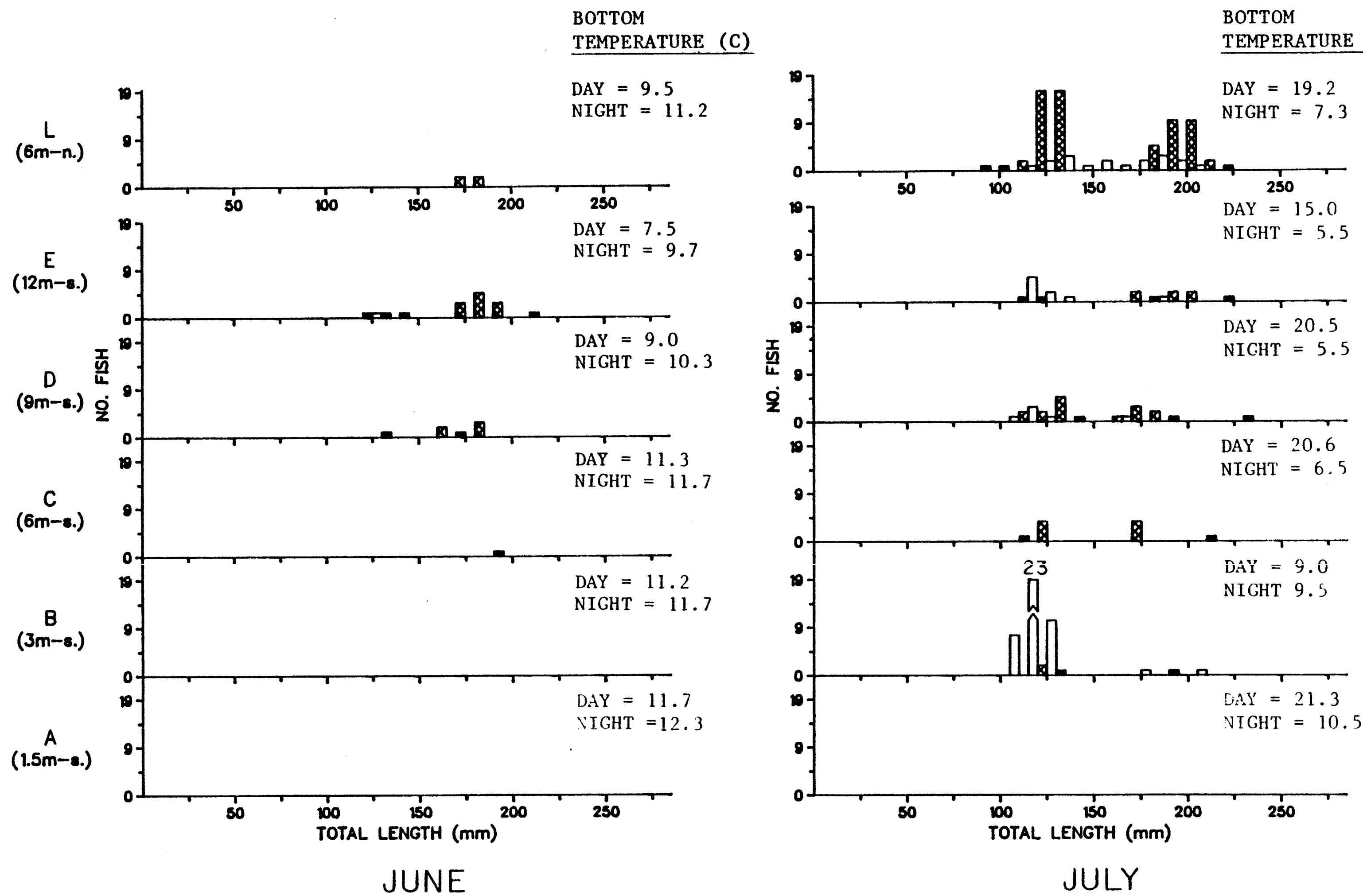


Fig. 42. Length-frequency histograms for unidentified coregoninae caught in duplicate bottom gill nets during April-November 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. □ = day ■ = night.

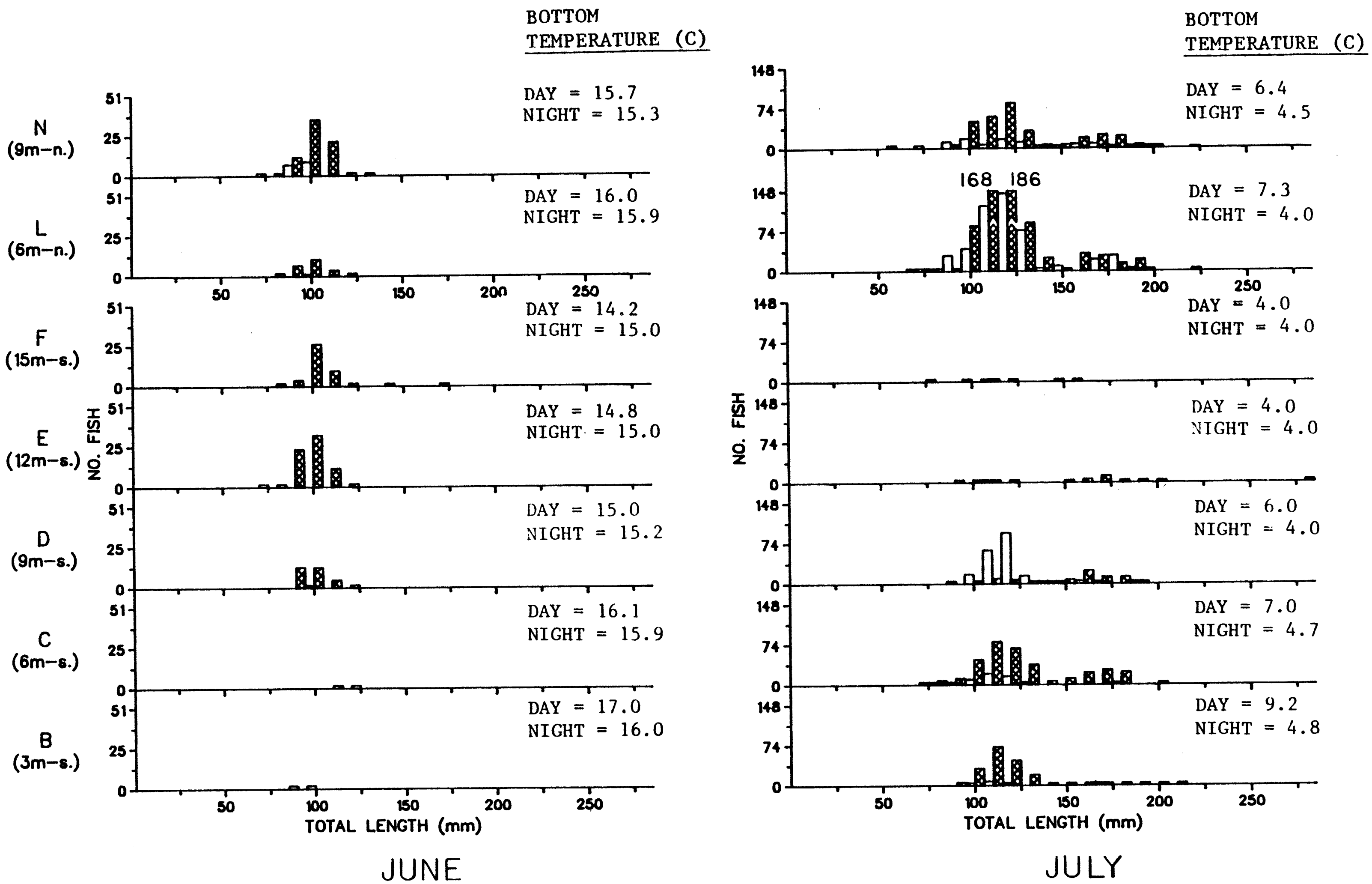
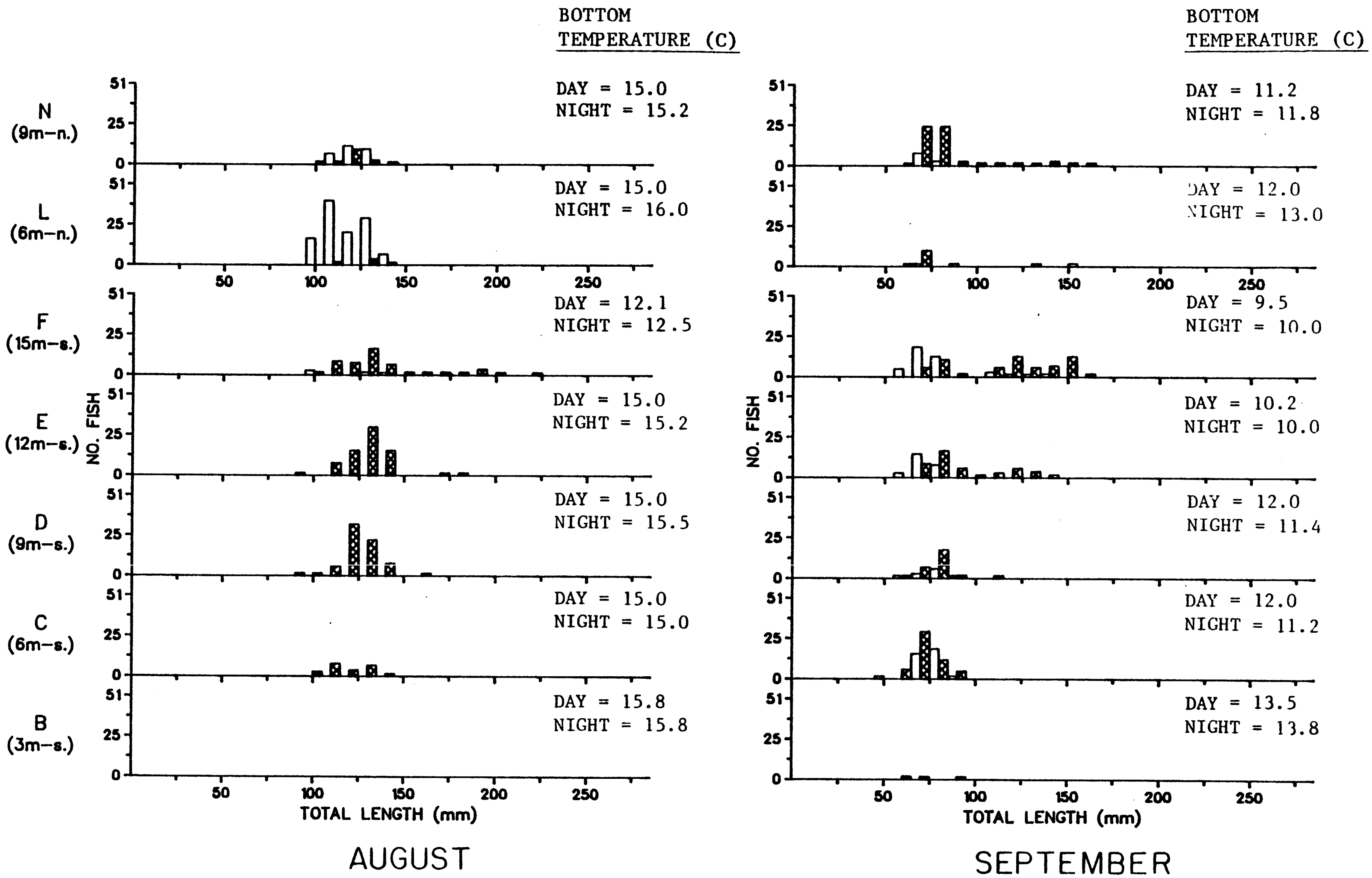


Fig. 43. Length-frequency histograms for unidentified coregoninae caught in duplicate trawl hauls during April to December 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. □ = day ■ = night * = no day sampling performed.



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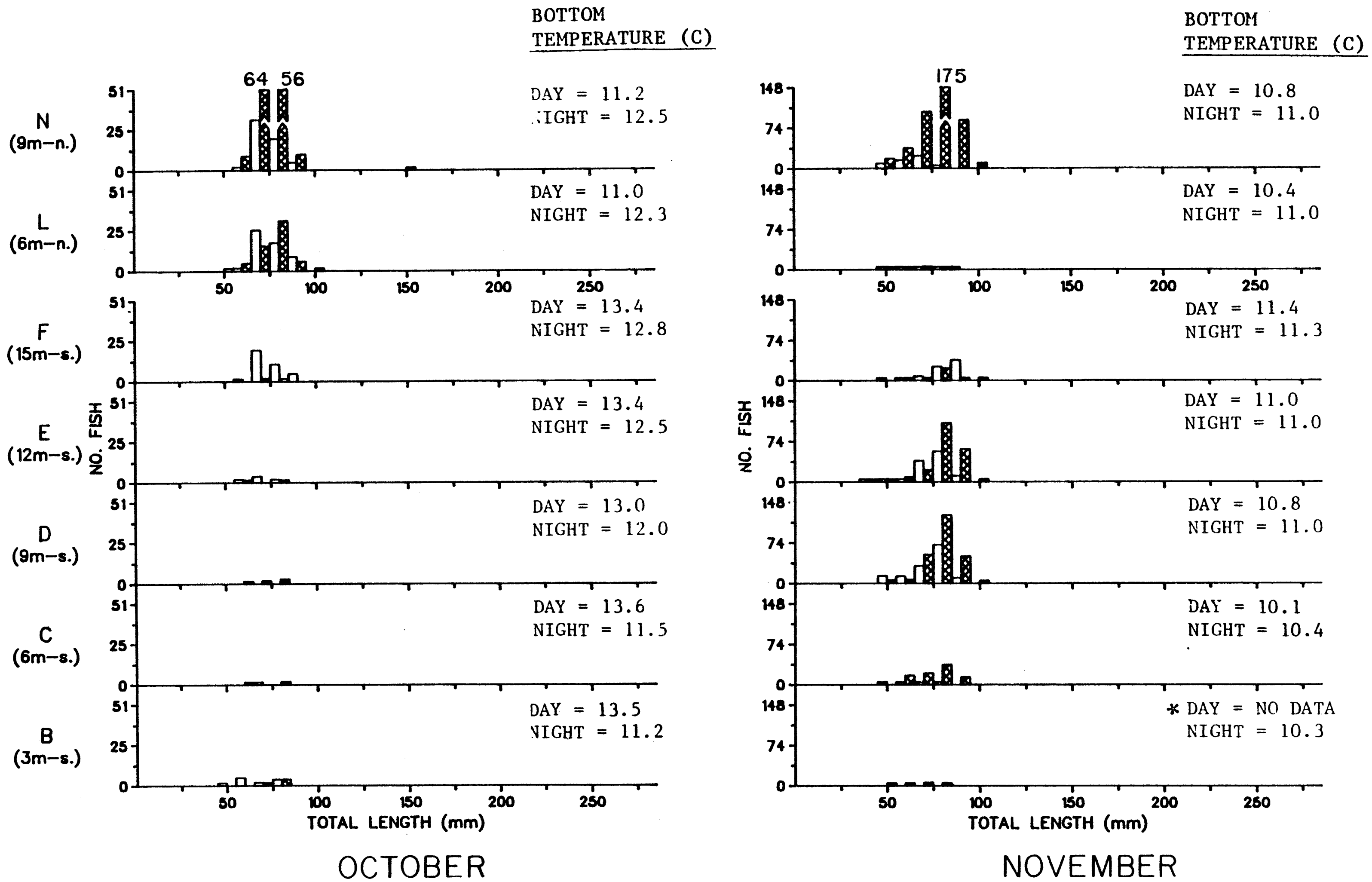

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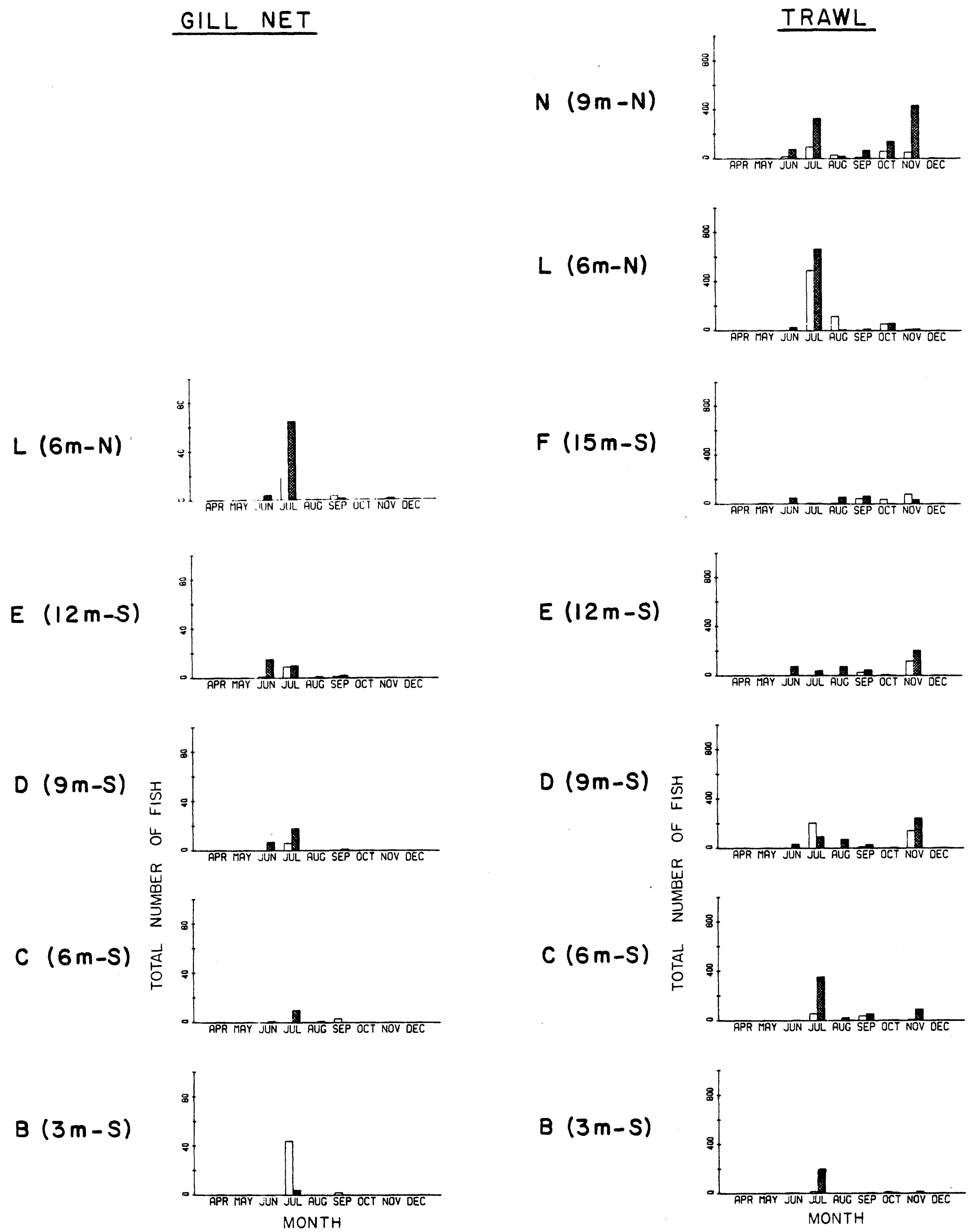


Fig. 44. Total number of unidentified coregoninae caught in duplicate bottom gill nets (left column) and duplicate trawl hauls (right column) during day and night once per month in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. Bottom gill nets were fished April to November 1979, trawl hauls were done April to December 1979. □ = day ■ = night * = no day sampling performed.

sets. Coregonines were also recovered from bottom gill net sets. Greatest catch again occurred at station L (6 m, south discharge) (Fig. 42). Water temperatures ranged from 9.5 to 5.5 C (7.3 C at station L).

Fish taken in July may belong to two age-groups. Those over 160 mm were considered mature 2-yr-olds or older fish. These fish averaged 173 mm (SE = 0.63, N = 567). This value is slightly below that of June (178 mm) probably due to increased numbers of smaller fish (Appendix 6). Yearlings caught in July averaged 115 mm (SE = 0.25, N = 2,163). One other yearling was collected in a plankton net tow at station C (6 m, south). This 105-mm fish was taken in a 6-m tow.

August--The yearling and 2+-yr-old unidentified coregonines began to move out of the study area during August. Of 405 fish collected, 15 were greater than 160 mm (average length = 181, SE = 4.36, N = 15). The remaining 390 fish were all thought to be yearlings (average length = 122, SE = 0.58, N = 390 - Fig. 41). Two small individuals between 120 and 130 mm, were caught in bottom gill nets set along the south transect at 6- and 12-m stations. The remaining coregonines were caught in trawls at all stations except B (3 m, south). Again, the largest catch occurred at station L (6 m, south discharge - Fig. 43). Water temperatures were warm, most being between 15 and 16 C, certainly not enough difference between transects to possibly account for the greater catch at L (6 m, south discharge). Secchi disc readings were also similar at both transects.

September--As was the case in 1978, most yearling bloaters occurred in our gear for the last time during the month of September (average length 131 mm, SE = 1.64, N = 85). September was also the last month in which the 2+-yr-old group of fish appeared (average length 189, SE = 11.37, N = 10 - Fig. 41).

Of the 429 unidentified coregonines caught in September, 334 were YOY (average length = 74 mm, SE = 0.42, N = 334). YOY first appeared in our adult sampling gear during this month in both 1978 and 1979 (Fig. 41).

During September, 410 fish were collected by trawls, 13 in bottom gill net sets and 6 by shore seining. Individuals seined were recovered at beach stations Q (south discharge) and R (north discharge) during the day in water 14.6 to 14.7 C. At least one coregonine was collected at each of the stations where bottom gill net gear was set except the 1.5-m station.

Once again, young coregonines were most abundant in trawls (Fig. 43). No pattern to their distribution seemed evident, most being caught at 6 to 15 m at the south transect and at 9 m on the north transect. Water temperatures at these stations ranged from 9.5 to 12.0 C, while those at remaining stations B (3 m, south) and L (6 m, south discharge) were 12.0 C or greater. A single 70-mm specimen was also collected during September in a day seine at Pigeon Lake station S (influenced by Lake Michigan); water temperature was 12.3 C.

October--With the exception of one 150-mm fish, all coregonines caught in October were thought to be YOY (average length = 75.0 mm, SE = 0.40, N = 391). These fish were collected exclusively in trawls; most (315) at north transect stations L (6 m, south discharge) and N (9 m, north) (Fig. 43).

During October, Secchi disc readings as well as water temperatures were lower at these north transect stations than values reported for the comparable south transect stations (C and D) and the rest of the reference transect. Water temperatures at stations C and D ranged from 11.5 to 13.6 C, while those at equivalent stations near the discharge (L and N) ranged from 11.0 to 12.5 C. These readings combined with water transparency readings of 3.9 and 4.5 m at 6- and 9-m stations C and D compared to 2.0 m at stations N and L, may account for the difference in number of unidentified coregonines captured. Unidentified coregonines may not have been able to see and avoid the trawl in the turbid waters caused by dredging and other construction activities at the north transect as they appeared to do at the south transect. An upwelling, responsible for cool temperatures, may have led them into the area.

November--The second greatest catch of unidentified coregonines occurred in November. Again, all but one of the 1,431 fish collected were YOY (average length 77 mm, SE = 0.28, N = 1,430 - Fig. 41). These YOY were taken in trawl hauls at all stations, occurring most abundantly at the 9- and 12- m stations along the south transect and at station N (9 m, north - Fig. 43). At this time, temperature and Secchi disc readings (10.1-11.4 C and 2.25-2.75 m respectively) were similar at both transects. The single large individual captured (238 mm) was taken in a bottom gill net set at station L (6 m, south discharge).

December--The drastic decline in temperature between November and December may have been responsible for the low catch (9) of unidentified coregonines during this month. These coregonines, believed to be YOY, were taken between 9 and 12 m at both transects in water 4 to 5 C and averaged 82 mm (SE = 4.0, N = 9) at both transects.

Temperature-catch relationships--Yearling and 2-yr-old unidentified coregonines caught predominately during June, July and August occurred most often in water 3 to 7 C (Fig. 45). YOY coregonines obtained during September to December most often were recovered in water 11-15 C. Similar trends were observed in 1978, but they were not so distinct (Jude et al. 1979a).

Impingement--Prior to 1978, coregonines had not occurred in impingement samples. Eleven immature coregonines were recovered from impingement samples during 1978. These fish were probably all YOY (53 to 93 mm) and were seen in September, October and November samples. Estimated impingement for 1978 was calculated to be 69 fish.

During 1979, 10 unidentified coregonines were examined from impingement samples resulting in a total loss estimate for the year of 68 fish. These fish ranged from 50 to 100 mm and were collected in September, October and November. Most were probably YOY as evidenced by the growth pattern exhibited by unidentified coregonines in our area.

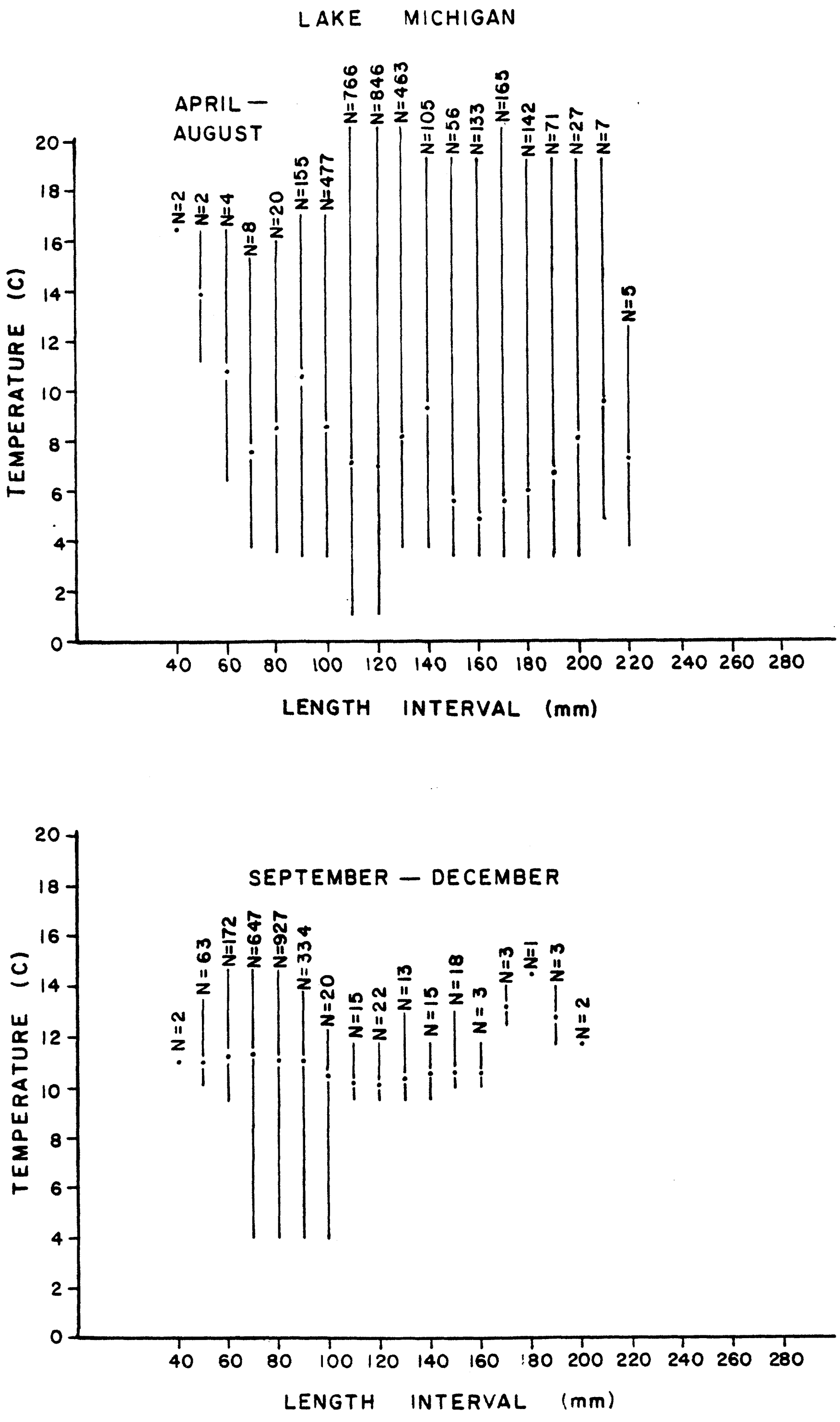


Fig. 45. Weighted-mean water temperatures at which various sizes (10-mm length groups) of unidentified coregonines were collected by all gear types from Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan, 1979. Vertical bars represent the range, N = number of fish.

Growth and development--During 1978 two distinct size groups of unidentified coregonines were evident (Jude et al. 1979a). YOY, less than 90 mm, were collected in the fall and age-group 1 + individuals greater than 90 mm were observed during the summer (Fig. 41). Whereas, only two size groups were clearly evident in 1978, due to increased catch in 1979 at least three size groups of unidentified coregonines appeared. YOY (less than 90 mm) again appeared in autumn samples; while from May to September, two additional size groups of coregonines were evident. Coregonines 90 to 160 mm (yearlings) were extremely abundant in trawl hauls (Fig. 41) while numerous individuals greater than 160 mm (age-group 2 +) were collected in bottom gill net sets, primarily during July. Many of these fish, particularly those over 200 mm, showed slight to moderate gonad development (Table 26).

Plant impacts--The current onshore intake and discharge system of the J. H. Campbell Plant has had little influence on the population of unidentified coregonines which exist in the area. These species prefer the more static, deep cool water which is found farther offshore beyond the immediate intake and discharge areas. Unidentified coregonines rarely occurred in 1977 samples and even though these species have shown a significant increase in population size during the past 3 yr, impingement of adult fish has remained consistently low. During 1978 and 1979, operation of the plant was estimated to have caused impingement of 69 and 68 unidentified coregonines, respectively. During the 3-yr study period, 13 larval coregonines were recovered in sampling efforts, 4 of which occurred in entrainment samples. The resulting estimated entrainment of these species for 1978 and 1979 was 22,900 and 607 larvae, respectively. The number of both adult and larval unidentified coregonines impinged and entrained by the current operation of the Campbell Plant is extremely low when compared to the size of the population found in the vicinity of the plant. Coregonines prefer cool, deep water and seldom enter Pigeon Lake, a necessary step to becoming impinged or entrained.

As can be seen from the 1979 data, unidentified coregonines were abundant during the summer months at depths greater than 6 m. The future operation of the offshore intake (11.5 m) and discharge (6 m) for Unit 3 could influence the distribution of this species in the area.

Summary--During the 3-yr preoperational study, catches of unidentified coregonines increased significantly. Seven percent of the total number of fish collected from Lake Michigan during 1979 belonged to this group. These coregonines are believed to be "bloaters", a species which prefers deep water (30 to 100 m). Those fish collected in our study may represent only the fringe of a more concentrated population farther offshore.

Trawling operations revealed young individuals (60-160 mm) were abundant from June through November at depths greater than 6 m. Older fish (greater than 160 mm) were caught predominately in bottom gill nets set at 6 m or greater most commonly in July. Obvious gear selectivity is evident as well as net avoidance, since few individuals less than 60 mm were collected by gill nets.

Table 26. Monthly gonad conditions of unidentified coregoninae caught during 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. All fish examined in a month were included except poorly received specimens.

	Gonad condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Males	Slight development			9	102	6	7	1	1	
	Mod. development				15		4			
	Well developed									
	Ripe-running									
	Spent									
Females	Slight development			10	117	7	4			
	Mod. development			1	34			2		
	Well developed									
	Ripe-running									
	Spent									
	Absorbing									
Immature			7	195	569	224	266	202	442	9
Unable to distinguish			1	4	82	3	13	2		

Catches overall, but particularly during July and November, were significantly greater at north transect stations L (6 m) and N (9 m) than at comparable south transect stations C and D. Secchi disc readings (which indicate degree of water clarity and thus degree of gear avoidance by fish) or water temperatures were not significantly different between these transects during these months. Perhaps discharge water and/or dredging operations in the vicinity had some effect on food organism abundance which in turn influenced distribution of the coregonines.

These unidentified coregonines supported a commercial fishery until its closure in 1976. The final effect of the closing, which is confounded somewhat by a decline in a competing species, alewife, is exhibited in the increasing populations of this group in southeastern Lake Michigan.

Trout-perch--

Introduction--Trout-perch inhabit all the Great Lakes and a few of the larger inland lakes (Hubbs and Lagler 1958). In Lake Michigan this species occurs most commonly in shoal areas, but may range into water as deep as 94 m (House and Wells 1973).

Trout-perch was one of the most abundant species collected near the Campbell Plant; most were caught in Lake Michigan. Trout-perch made up approximately 1.1% of the total catch in Lake Michigan in 1977 and slightly more than 2% both in 1978 and in 1979. Trout-perch were caught mostly in trawls during 1977 through 1979. A small number were collected in Pigeon Lake during 1979; relatively few were impinged on the traveling screens of the Campbell Plant.

Seasonal distribution--

April--Three trout-perch were seined at night in April (Fig. 46); they were all adult females with moderate to well developed gonads. Fish were seined at stations Q (south discharge) and P (south reference) (Table 27) and were probably attracted to the warm water of the beach zone. Two of the three fish were seined at beach station Q where water temperature was higher than at other nearshore areas (Appendices 1-3). One adult trout-perch was caught in a bottom gill net at station L (6 m, north) at night (Figs. 47 and 48).

April marks the spring inshore migration of trout-perch in Lake Michigan. It appears only a few trout-perch had migrated inshore in the vicinity of the Campbell Plant by sampling time. This was also true for April 1978 when only 11 fish were captured.

Jude et al. (1979a) reported that spawning of trout-perch in the area of the Campbell Plant extended from April through September during 1978. Gonad data for 1979 suggest a spawning season from May through July (Table 27). However, trout-perch larvae (6-7 mm in length) caught in April indicate spawning in the plant vicinity during April. Spawning may have continued on to September since a 6.8-mm larva was collected at station D (9 m, south) on 19 September.

May--Migration of trout-perch inshore increased markedly from April to May. Substantial numbers of yearlings (99) and adults (341) were collected; most fish were caught in trawls at night (Appendices 6-7). Trout-perch were caught from the beach zone to 15 m with most being trawled from 6 to 12 m (Fig. 47).

Yearlings this month, based on length-frequency data, ranged in length from 15 to 64 mm with 40 mm being the modal interval (Appendix 6). Length of age-2 fish ranged from approximately 65 to 104 mm and age-3 fish ranged from 95 to 124 mm. Age-2 fish were separated from age-3 fish based on length-frequency data and by comparison with data from the study by House and Wells (1973), who aged fish by reading scales.

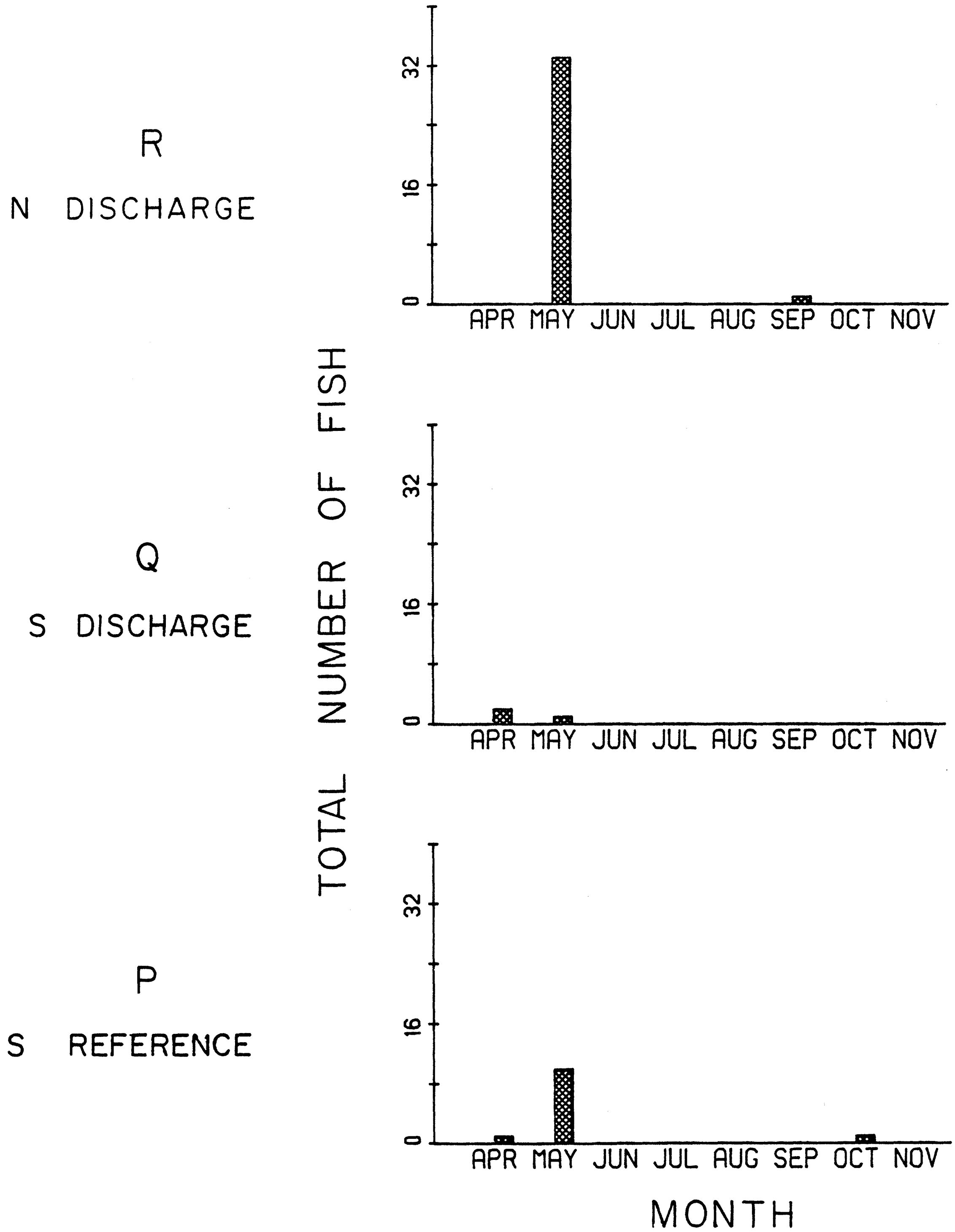


Fig. 46. Total-number of trout-perch caught in duplicate seine hauls during day and night once per month April to November 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. □ = day ■ = night.

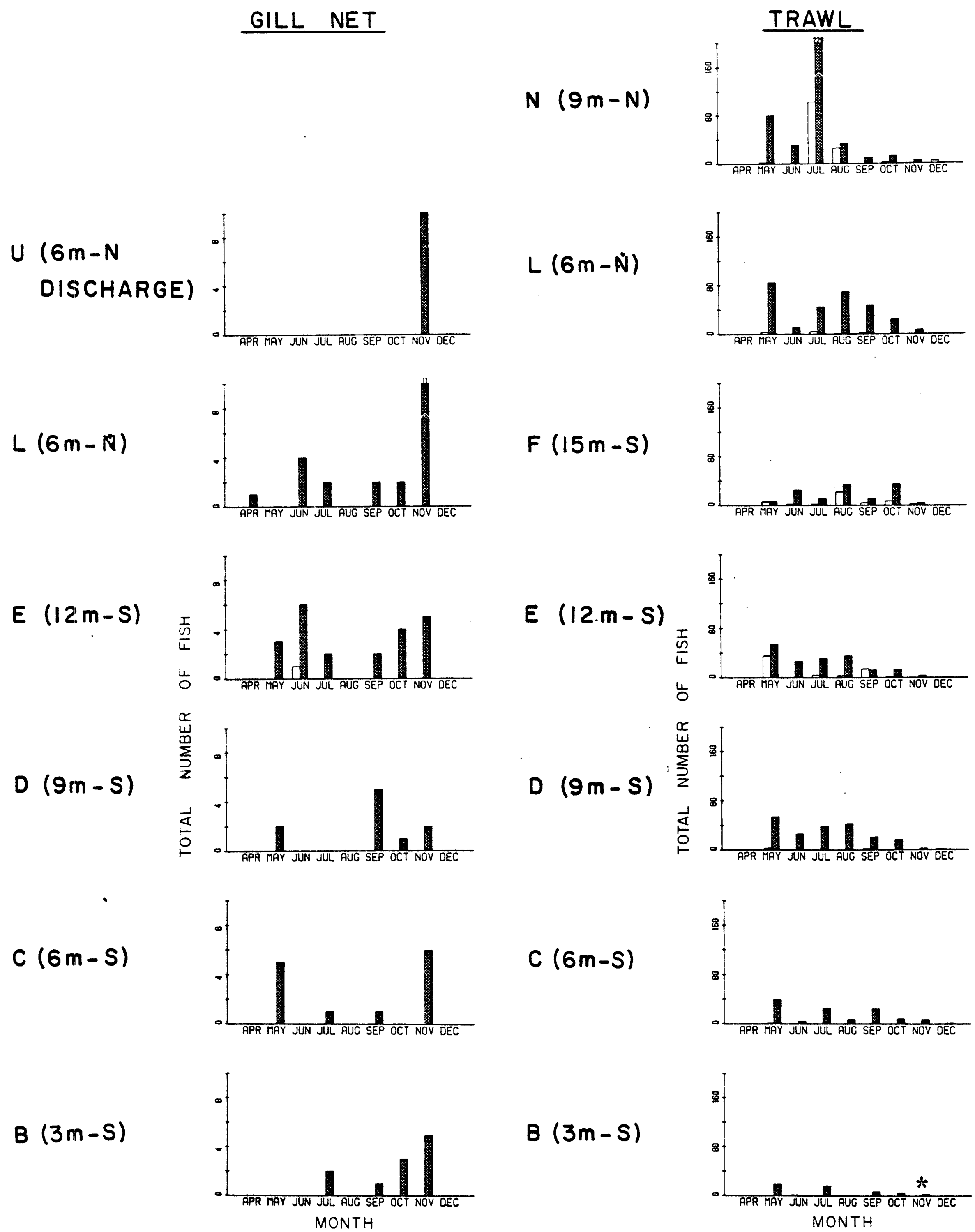


Fig. 47. Total number of trout-perch caught in duplicate bottom gill nets (left column) and duplicate trawl hauls (right column) during day and night once per month in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. Bottom gill nets were fished April to November 1979, trawl hauls were done April to December 1979. □ = day ■ = night * = no day sampling performed + = no sampling performed.

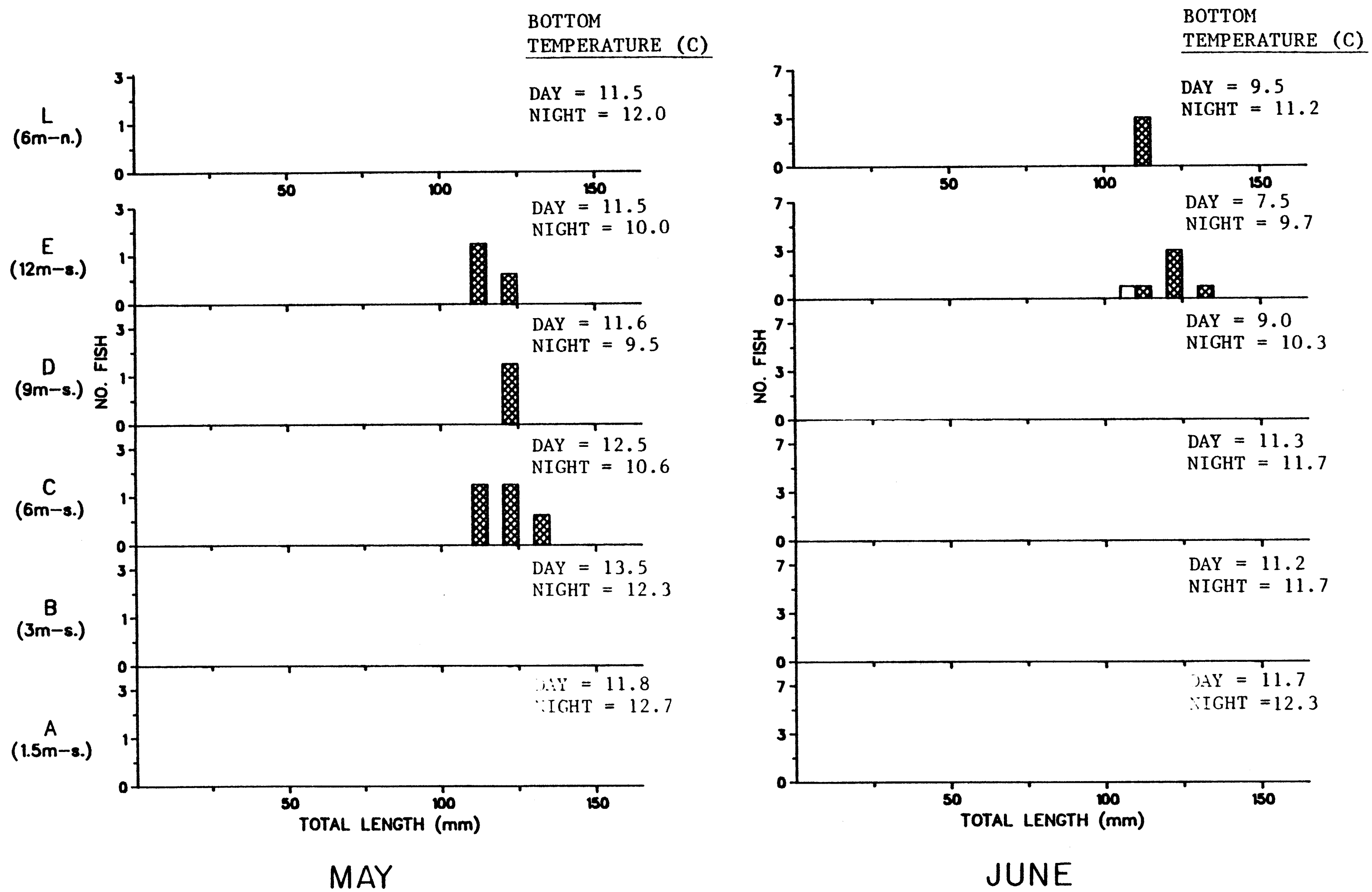


Fig. 48. Length-frequency histograms for trout-perch caught in duplicate bottom gill nets during April-November 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. □ = day ■ = night + = no sampling performed.

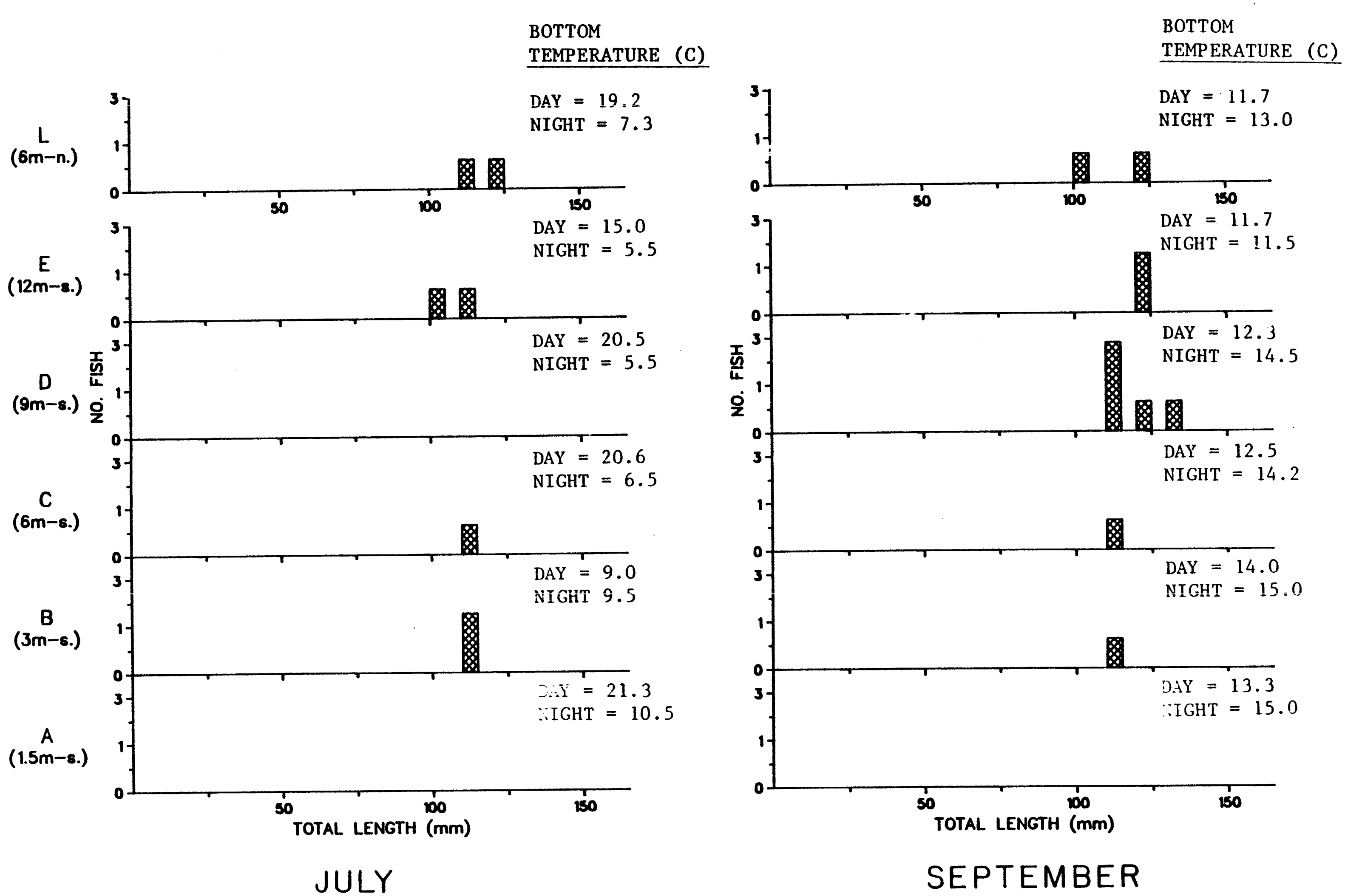


Fig. 48. Continued.

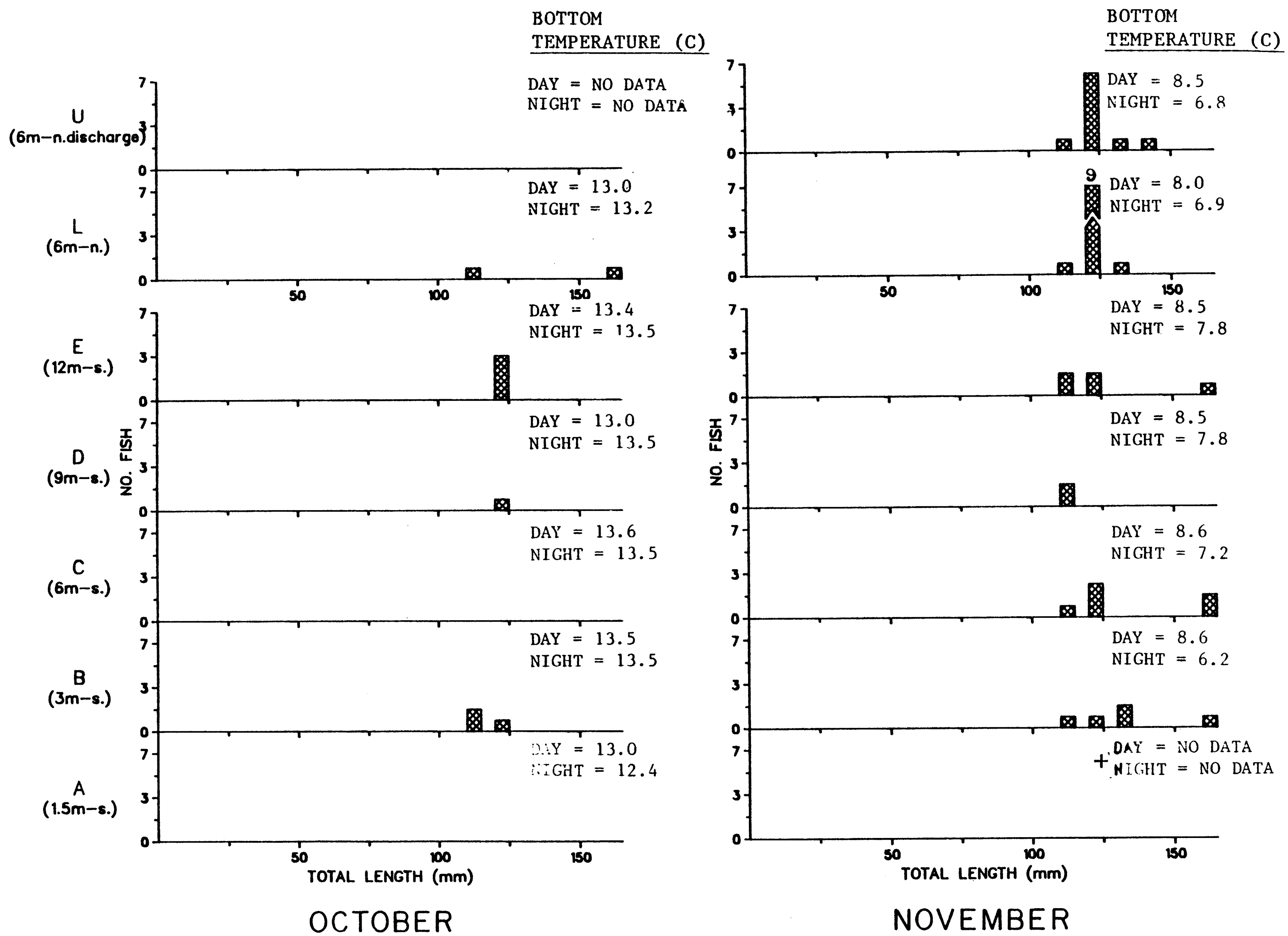


Fig. 48. Continued.

Trawl catch data showed yearlings were most common at 9 m and deeper and at station L (6 m, north) (Fig. 49). They were caught during the day from 6 out to 15 m and at night from 3 to 15 m. No yearlings were seined during May. Adults were using the inshore area extensively during May, being caught from 6 to 15 m during the day and from the beach to 15 m at night (Fig. 46). Forty-four adults were seined, 33 at station R (north discharge), 1 at Q (south discharge) and 10 at P (south reference). Night temperature at station R (north discharge, beach) was slightly higher than that for the south discharge beach station Q (13.5 C vs. 13.0 C) which might partially explain the marked preference of trout-perch for station R. Catches were relatively low for seines throughout the study period compared to trawl catches. Trout-perch do not prefer the beach zone, but seem to prefer 6- to 12-m water. Adults were also caught in bottom gill nets at the south transect: five at station C (6 m), two at D (9 m) and two at station E (12 m) (Fig. 48). All were caught at night, which may partially be explained by avoidance of gill nets during the day. Gill nets are not very effective gear for catching trout-perch as numbers caught by this gear were relatively small for the entire study period.

During May and throughout the study period, as during the previous 2 yr, trout-perch exhibited a pronounced diel migration characterized by a movement to shallow areas at night and a return to deep water during the day. Night catches were consistently higher than day catches. This migration was consistent for both adults and yearlings throughout the period of study; there were few exceptions to this pattern. Indeed, the difference between day and night catches was more pronounced for trout-perch than for any other major species; and the ANOVA test (see RESULTS AND DISCUSSION-STATISTICS) for diel period differences in trawl catches for trout-perch was the most significant of all tests performed for all major species.

Spawning activity in May increased from April levels as more fish with well developed gonads were caught; seven spent trout-perch were also taken (Table 27). This increased spawning activity paralleled the spawning schedule of trout-perch in 1978.

The number of adults caught in May 1979 was similar to the number caught in May 1978. However, the May catch in 1978 was mostly (over 75%) 2-yr-old fish. These fish were members of the strong year class of 1976 noted by Jude et al. (1978, 1979a). The adult catch for 1979 was composed largely of 3-yr-old fish which again represented the strong 1976 year class; apparently this year class survived the winter well and was present in relatively high numbers in May. The number of age-2 fish collected in 1979 was not as high as in 1978; these fish represent the relatively weak yearling age-group of 1978. Whereas the yearling age-group was weak in 1978, yearlings in 1979 were collected in relatively high numbers. Most trout-perch mature by age 2 (House and Wells 1973) so that the 1976 year class was probably the major parent stock for this yearling age-group. In this case, the large 2-yr-old stock in 1978 apparently was the major parent stock for the 1979 yearling group. However, Magnuson and Smith (1963) found environmental conditions were more important in the formation of a strong age-1 year class in Red Lakes, Minnesota than did size of the parent stock.

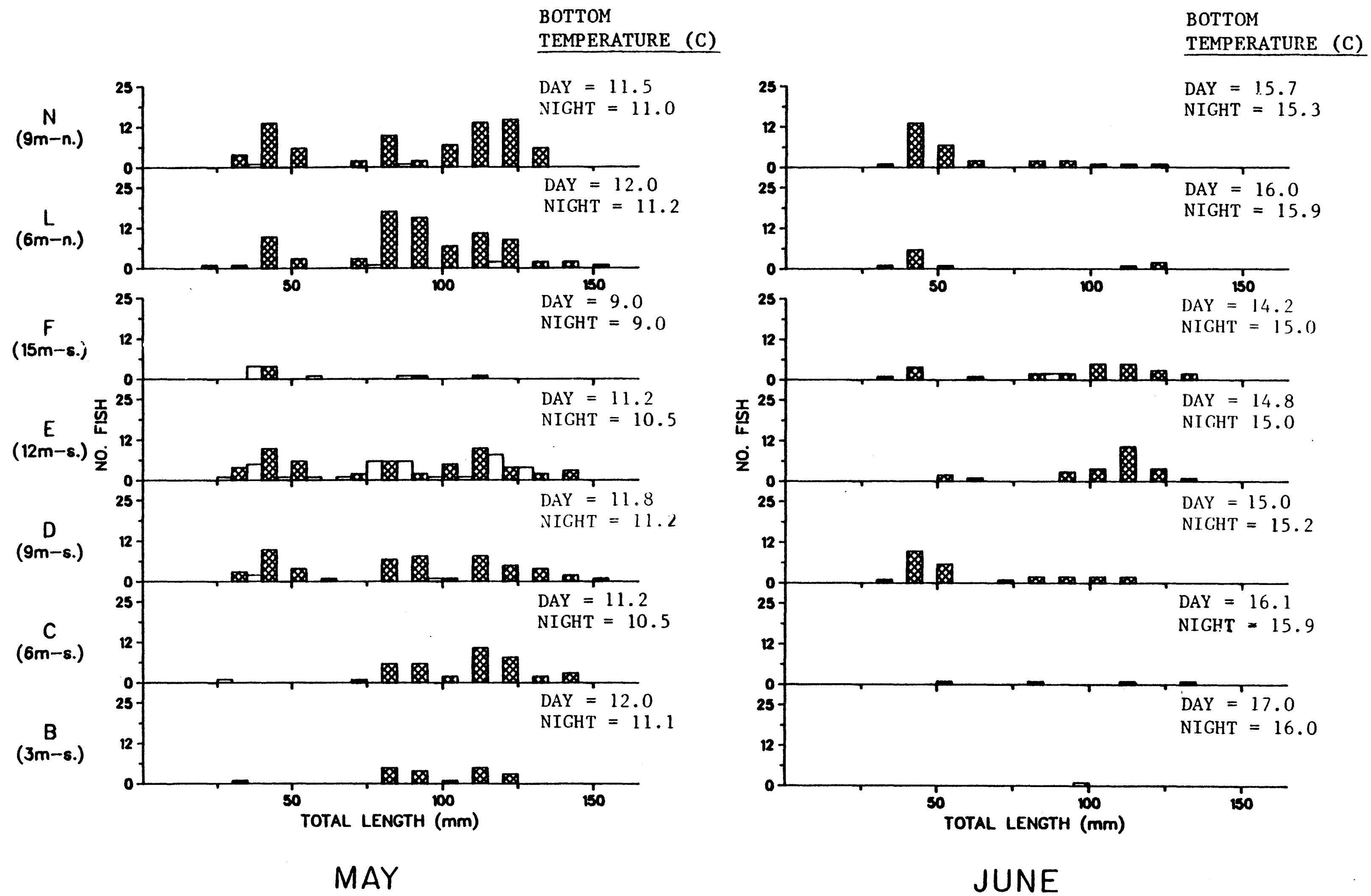


Fig. 49. Length-frequency histograms for trout-perch caught in duplicate trawl hauls during April to December 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. □ = day ■ = night * = no day sampling performed.

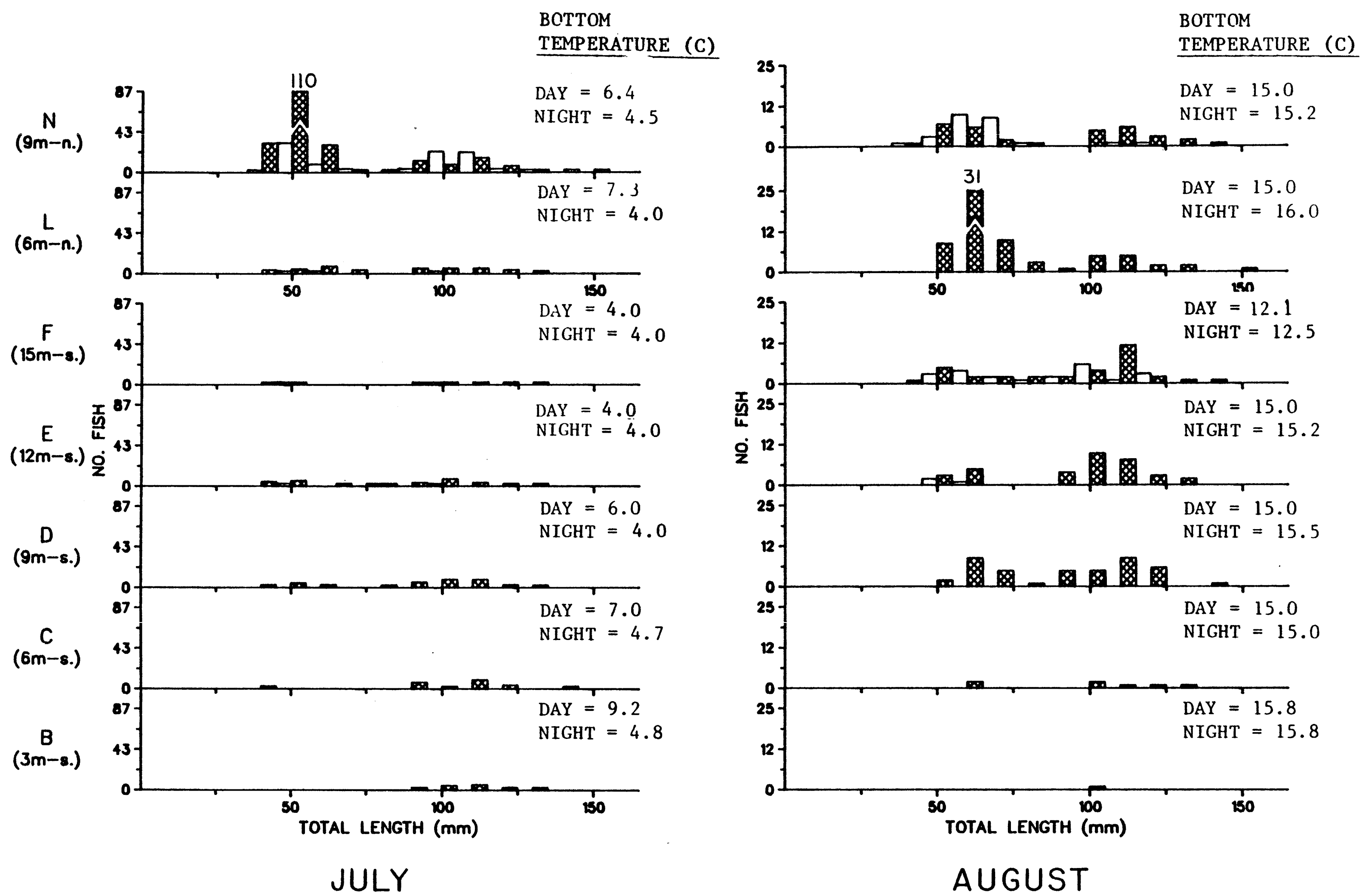


Fig. 49. Continued.

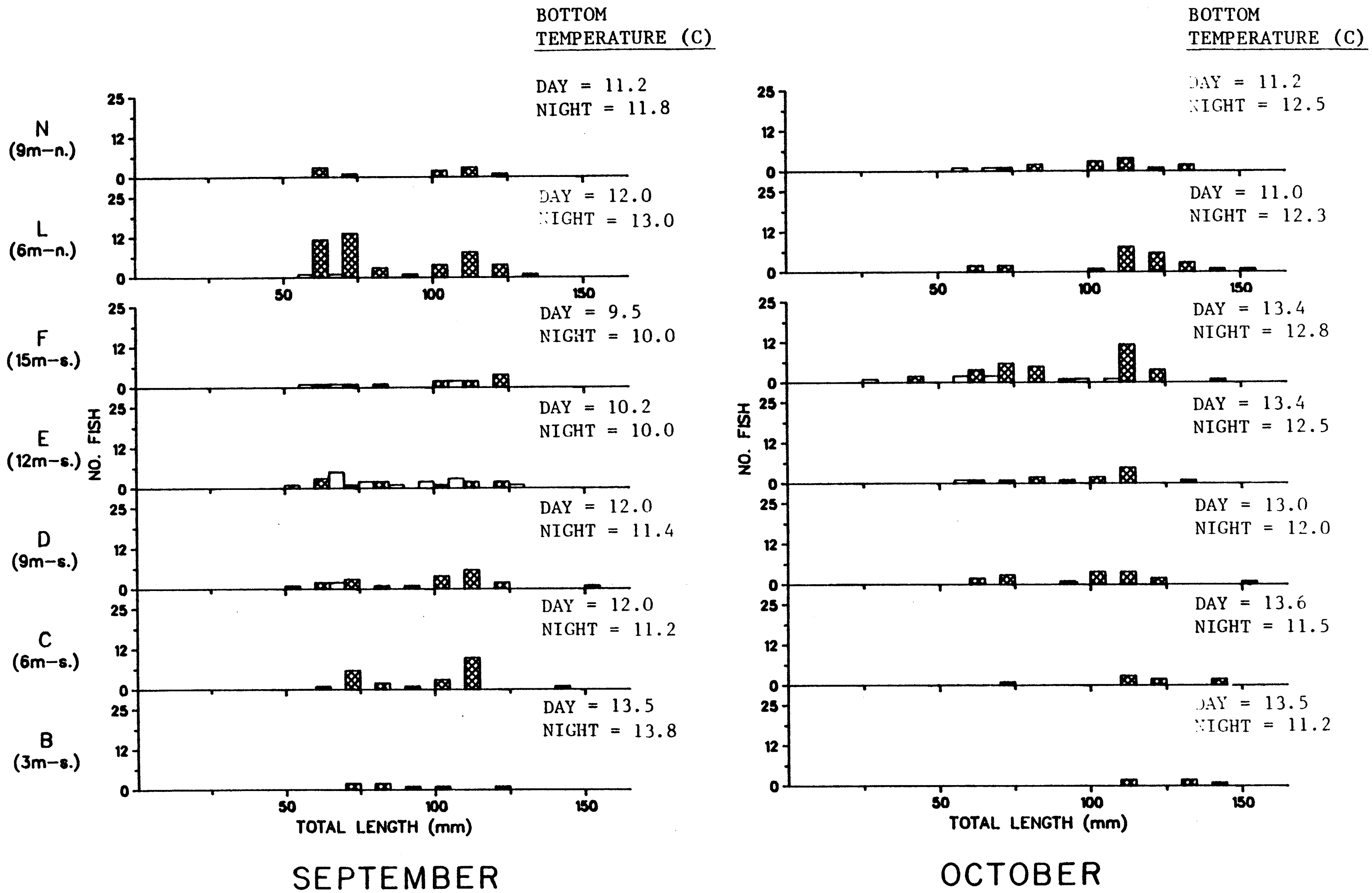


Fig. 49. Continued.

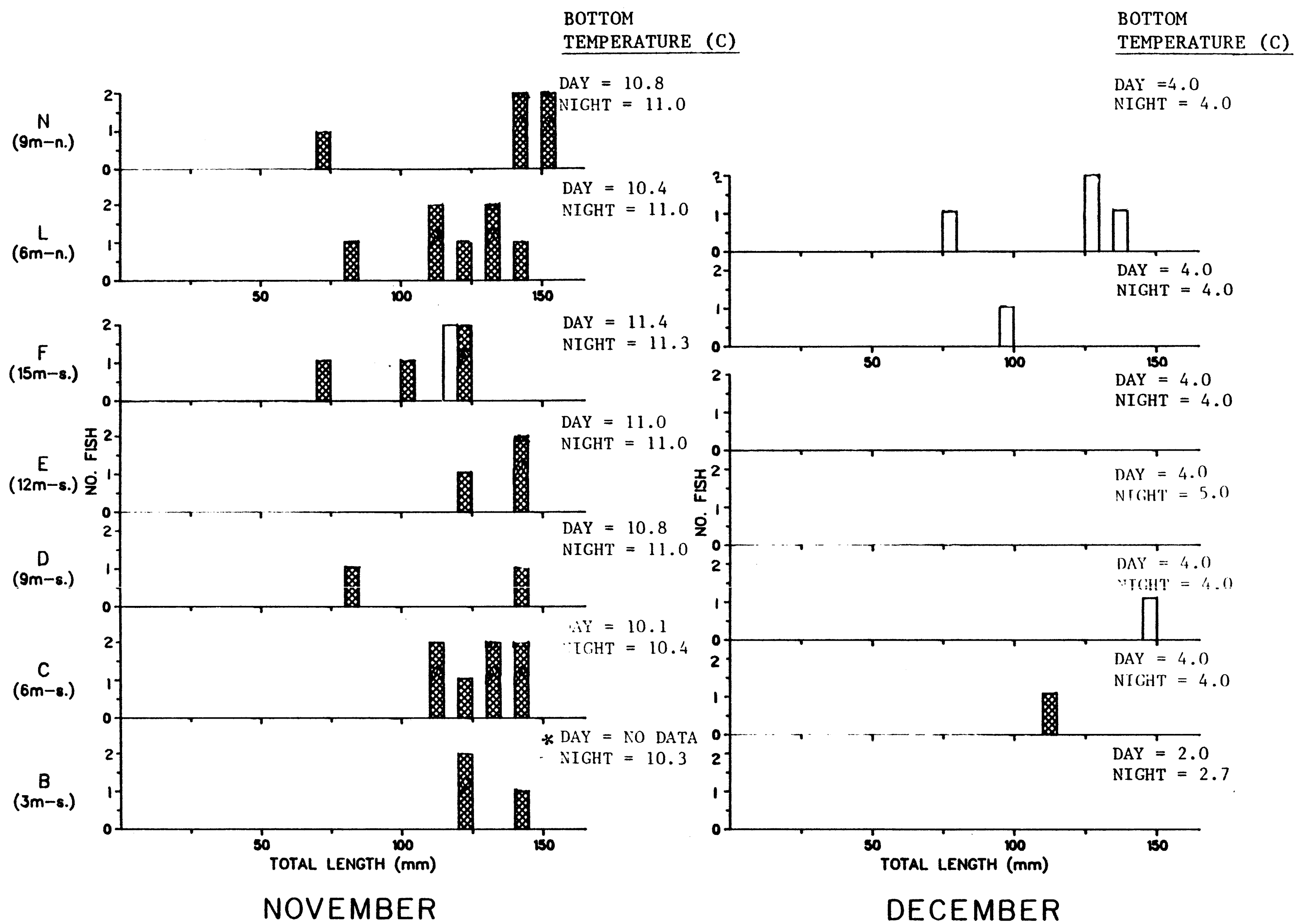


Fig. 49. Continued.

June--Catches in June declined substantially from May (Appendix 6). Reasons for this decline are not known; there was no upwelling at sampling time which could have affected trout-perch distribution. Bottom temperatures for trawling ranged from 14 to 17 C. In 1977 and 1978, peak catches were recorded in June.

The yearling (25-64 mm, 40-mm modal length interval) catch decreased somewhat from May. Yearlings were caught from 9 to 15 m during the day and from 6 to 15 m at night. Data for 1977 and 1978, as do data for 1979, show that yearlings are generally restricted to 9 m or deeper during the day. No yearlings were caught in seines or gill nets during June. Gill net meshes are probably too large to catch yearlings, since none were taken from 1977 to 1979

Adults (65 mm or greater) were caught from 3 to 15 m during the day and 6 to 15 m at night. Numbers of adults caught declined drastically between May and June. No adults were caught in seines, but several were caught in bottom gill nets; six were caught at station E (12 m, south) at night, one at station E during the day, and four at station L (6 m, north) at night (Figs. 47 and 48).

In June trout-perch were most common between 6 and 12 m; there appeared to be no spatial or temporal separation between yearlings and adults. Again, the high night catches and very low day catches indicate a migration of trout-perch into the study area at night and into deeper water during the day. Net avoidance probably also reduced day catches.

Gonad data suggest a spawning peak in June, even with the reduced numbers of adults caught (Table 27). The first trout-perch with ripe-running gonads were collected in June. The spawning peak may have occurred just before our sampling period in June, with most fish leaving the vicinity immediately after spawning. In 1977 and 1978 the spawning peak occurred in June, but unlike 1979, spawning peaks in prior years coincided with peak catches. Adults in 1979 may have suffered high mortality losses after spawning as has been noted by Scott and Crossman (1973).

July--Numbers of trout-perch caught peaked in July partially due to an influx of yearlings into the study area. Yearlings (35-74 mm, 50-mm modal length interval) were caught from 6 to 15 m during the day and night. Relatively high numbers of yearlings were caught at station N (9 m, north transect), particularly at night (Fig. 49). The number of yearlings caught in July was substantially higher than for May or June; July yearlings may have migrated from deeper water and entered the study area with upwellings. All July trawling was performed during an upwelling with bottom temperatures ranging from 4.0 to 9.2 C; at station N (9 m, north), the night temperature was 4.5 C and the day temperature was 6.4 C. Reasons for high catch at station N are not clear although temperatures at station N were slightly higher than those for other trawling stations of 6 m or greater depths.

Table 27. Monthly gonad conditions of trout-perch caught during 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. All fish examined in a month were included except poorly received specimens.

	Gonad condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Slight development		32	8	8	30	47	31	9	2
	Mod. development		91	10	60	29	20	19	26	
Males	Well developed		5	18	38	1				
	Ripe-running			2						
	Spent		4	1	4					
	Slight development		43	5	19	15	34	35	3	2
	Mod. development	3	106	8	16	38	19	15	29	2
Females	Well developed	1	19	13	41	18	1	1	3	
	Ripe-running			10	9					
	Spent		3	4	8					
	Absorbing				2			1		
Immature			104	58	144	103	27	23	1	1
Unable to distinguish			3		2	5	11	7	1	

Adults were caught from 6 to 15 m during the day and from 3 to 15 m at night. Relatively high numbers of adults were caught at the 9-m north transect station, particularly during the day (Fig. 49). No adults were caught in seines during July in Lake Michigan, although a few were caught in bottom gill nets (Figs. 47 and 48).

Most trout-perch were caught at stations 9 to 15 m at the south transect and stations 6 to 9 m at the north transect. Again, both adults and yearlings exhibited migrations shoreward at night and into deeper water during the day with the exception of adults at station N (9 m, north) where day catch was greater than night catch (Fig. 49).

There appears to be a secondary peak in spawning during July as nine individuals with ripe-running gonads were collected (in June, 12 such individuals were caught - Table 27). Peak spawning occurred in June during 1977 and 1978 in the study area, but peak spawning has been reported for July for the Cook Plant vicinity (Jude et al. 1979b). In 1977 at the Campbell Plant, there appeared to be a secondary spawning peak in August.

Substantially more adults were collected in July than in June. However peak catch of adults occurred in May. A high percentage of the adults caught in July were age 3.

August--Catch of trout-perch, both adults and yearlings, decreased considerably in August. Yearlings (45-74 mm, 60-mm modal length interval) were caught from 9 to 15 m during the day and 6 to 15 m at night. Adults were caught from 9- to 15-m depths during the day and 3 to 15 m at night. As for most 1979 months, most trout-perch were caught at stations 9 to 15 m at the south transect and at 6- and 9-m stations at the north transect. Yearlings and adults migrated toward shore at night and toward deeper water during the day; the only exception was a group of yearlings at station N (9 m, north) (Fig. 49).

Numbers of individuals collected with well developed gonads decreased in August and no trout-perch with ripe-running gonads were caught (Table 27). These gonad data were not a strong indication of continued spawning in August. However, a 6.8-mm trout-perch larva (see Trout-perch-FISH LARVAE AND FISH EGGS) collected at station D (9 m, south) on 19 September suggested spawning continued through late August and possibly early September. The length at hatching for trout-perch is reported to be about 5.5 m (Jude et al. 1979a).

September--Abundance of yearlings and adults in the Cook Plant study area declined in September in southeastern Lake Michigan (Jude et al. 1975). In 1978 the major portion of the trout-perch population in the Campbell Plant area of Lake Michigan had left by sampling time in September (Jude et al. 1979a). Catch data for 1979 for the Campbell Plant area indicated a movement offshore beginning in August and continuing through September.

Yearlings (45-94 mm, 70-mm modal length interval) were found from 6 to 15 m during the day and from 3 to 15 m at night. In 1977 yearlings did not start their offshore migration from the study area until October, but in 1979 catch data showed this migration was well underway by September.

Adults were found from 9 to 15 m during the day and from the beach to 15 m at night (Figs. 47 to 49). Only one adult was caught in a seine at beach station R (north discharge) at night (Fig. 46). Eleven adults were caught at night in bottom gill nets (Fig. 48).

October--The number of yearlings caught continued to decline in October, however, the abundance of adults in the study area appeared to remain the same as for September. Yearlings were caught from 9 to 15 m during the day and from 6 to 15 m at night. One yearling was caught in a seine at beach station P (south reference) at night (Fig. 46). Adults were caught only at 15 m during the day and from 3 to 15 m at night. Again, both adults and yearlings exhibited a movement toward shore at night and away from shore during the day. Ten adults were taken in gill nets in October; all were caught at night (Fig. 48).

Three YOY trout-perch (25-44 mm) were caught in trawls at station F (15 m, south) in October (Appendix 6). In both 1977 and 1978, only a few non-larval YOY were caught and these fish were captured between September and December. As in 1979, these fish were caught at deepwater stations. Since YOY trout-perch move offshore during summer (Magnuson and Smith 1963), it is likely that most YOY had already entered offshore water outside the study area by the time they became susceptible to trawls.

November and December--Most yearlings had left the study area by November. Number of adults collected declined somewhat from October levels. Almost all trout-perch were caught at night (two adults were caught during the day at 15 m, south transect). Bottom gill net catches peaked in November with 39 adults being caught at night (Fig. 48). Five adults were caught in a surface gill net at station C (6 m, south) at night. The trout-perch is considered a benthic species as most of these fish are caught near or at the lake bottom; however, apparently some move upward in the water column at times. One adult was caught in a night surface gill net in May 1978 at station L (6 m, north). By December, most trout-perch had left the study area; only five adults and two yearlings were caught in December (Appendix 6).

Thirty trout-perch were collected in Pigeon Lake in 1979; all were yearlings caught at night by seines at station S (Lake Michigan influenced). Only a few trout-perch were caught in 1977 and 1978 (4 and 15, respectively - Jude et al. 1979a), with most being caught at station S. During 1979, 1 trout-perch was caught in July, 2 in September and 22 in October. Water temperature at beach station S (Lake Michigan influenced Pigeon Lake) was near that for Lake Michigan (in fact, slightly lower than Lake Michigan beach stations) during September and October. Reasons for yearlings moving into Pigeon Lake are not clear. Data for 1977 through 1979 show no evidence of trout-perch spawning in Pigeon Lake.

Temperature-catch relationships--Trout-perch appeared to tolerate a wide range of water temperatures. During 1977 through 1979, most trout-perch were caught in water temperatures between 4 and 16 C in the study area.

Response of trout-perch to changes in water temperature varies considerably. In 1977 trout-perch catches increased with increasing water temperatures. In July 1978 an upwelling apparently caused a decline in the number of adults collected compared to June. However, in 1979 increasing water temperature from May to June did not lead to an increase in trout-perch catch. Also, when an upwelling occurred in July, higher numbers of trout-perch were collected than in June; water temperatures at times of trawling were considerably lower in July than in June. In southeastern Lake Michigan, trout-perch tended to move to warm water areas and remain indifferent or were attracted to cool water at other times (Jude et al. 1979b). In 1977 yearling trout-perch tended to occur in cooler water than adults in the study area; however, in 1978 and 1979 no pattern of temperature preference was apparent in catch data.

Other considerations--House and Wells (1973) found mean lengths of yearlings to be 49 mm in June and 83 mm by the end of the second year of life in southeastern Lake Michigan. For our study area in 1977, yearlings reached a modal length interval of 50 mm in June and 80 mm in September. In 1979 yearlings reached a modal length interval of 40 mm in June and 70 mm in September. Growth may have been slightly slower in 1979 than in 1977 due to lower water temperatures in July and August 1979.

Trout-perch were not found to be an important forage species in various areas of southeastern Lake Michigan (Jude et al. 1979b; House and Wells 1973). During our study from 1977 to 1979, trout-perch were seldom found in stomachs of predatory fishes.

Plant impacts--Trout-perch was one of the five most common species in the Lake Michigan study area from 1977 to 1979, but relatively few were impinged. In 1977, 604 trout-perch were estimated impinged from June to December (Zeitoun et al. 1978); 1283 trout-perch were estimated impinged in 1978 from January to December, and in 1979, an estimated 2063 trout-perch were impinged (January-December) during the study (see RESULTS AND DISCUSSION-IMPINGEMENT).

In general, numbers of trout-perch impinged were higher when inshore abundance in Lake Michigan was low. In 1979, impingement was relatively high from January to March, low from April through September, increased in October and was high in November and December. Highest impingement losses occurred in November. Numbers of trout-perch collected in impingement samples and corresponding numbers estimated impinged during 1979 were: January (48, 294), February (53, 369), March (44, 341), April (11, 80), May (2, 15), June (0, 0), July (1, 6), August (0, 0), September (5, 35), October (81, 124), November (78, 530) and December (17, 269). Perhaps during January through April, trout-perch were attracted to the warmer water of Pigeon Lake and later impinged. However, during October through November, water temperatures were similar for both lakes (inshore Lake Michigan and Pigeon Lake). Probably some trout-perch remained in the discharge canal during the winter (and possibly the entire year), but entered the intake forebay through a gate between the discharge canal and the forebay, and then were impinged. The gate was opened from November through April which corresponded to the months of highest impingement losses.

Operation of Campbell Plant Units 1 and 2 apparently has had little effect on trout-perch abundance. Trout-perch was a major species for all 3 yr of the study; the population appears to have increased from 1977 to 1978 and remained about the same from 1978 to 1979 (in 1978 there were 1861 fish caught in Lake Michigan, in 1979 there were 1755 caught). Impingement was relatively low with 1283 estimated impinged in 1978 and 2063 in 1979. ANOVA results (see RESULTS AND DISCUSSION-STATISTICS) showed no difference between trout-perch catches for stations C and L (6 m, south and north, respectively) for 1977 and 1978. However, for reasons unknown, in 1979 the catch at station L (discharge) was substantially higher than that for station C (reference). In 1978 an estimated 4,690 larvae were entrained, but in 1979 over 86,500 larvae were estimated entrained. Reasons for this increase are not clear, but these

numbers are still relatively low for a major species. Trout-perch have no present commercial or sport value; they are consumed infrequently by large predacious fish.

Summary--Trout-perch was one of the most common species found near the J. H. Campbell Plant. Trout-perch moved inshore in April and their abundance in the study area was apparently highest in May. Trout-perch catches declined gradually from August through December as trout-perch moved offshore. Small numbers of trout-perch were caught during the fall. The trawl was the most effective gear in collecting this species. Larvae data indicated trout-perch spawning had taken place as early as April and as late as September.

A major portion of the adult population was age-3 fish; these fish were members of the strong 1976 year class. Adult catches were relatively low after May; this may have been due to immediate migration from the area after spawning or perhaps there was a die-off after spawning. Adults were found from the beach to 15 m with most being caught between 6 and 12 m during spring and summer. Small populations of adults remained in the inshore area during fall. Yearlings occurred in relatively large numbers in 1979; these fish may be chiefly offspring of the 1976 year class. Most yearlings were caught between 6 and 12 m during the spring and summer and most had left the inshore area before November. Just three YOY trout-perch were caught in trawls; all in October in water 15 m deep. Night catches of trout-perch were significantly higher than day catches. Both adults and yearlings migrated toward shore at night and to deeper water during the day. Most trout-perch were caught at water temperatures between 4 and 16 C. This species showed considerable variation in temperature preference. Relatively low numbers of trout-perch were impinged.

Johnny Darter--

Introduction--In Lake Michigan during 1979, johnny darters were caught only in bottom trawls. Because of their small size and shape, johnny darters were not sampled by our gill nets. Absence of johnny darters from our beach seine hauls suggests little use of the beach zone by this species; very few were seined in Lake Michigan during 1977-1978. Bottom trawls collected 405 johnny darters; 55 were caught during the day and 350 at night.

Seasonal distribution - Lake Michigan--Only 11 johnny darters were caught during April; none were caught during April 1978. Numbers of johnny darters collected in May increased more than threefold from April levels when 11 were caught. These were all adult fish (34-75 mm) moving inshore to spawn. Gonad data (Table 28) indicated that johnny darters spawned during the period from late May to early August in 1979; five johnny darter larvae were caught during August 1979. Jude et al. (1975, 1979a) reported that johnny darters spawn during late May, June and July in southeastern Lake Michigan. It is suspected that johnny darters spawn on the bottom between 3 and 9 m in Lake Michigan near the J. H. Campbell Plant. Johnny darters spawn on the underside of rocks or gravel (Winn 1958). Winn (1958) also stated that johnny darter spawning occurred under fibrous pieces of sod which had broken loose from a river bank when rocky nesting sites were unavailable. It seems that this

species prefers to spawn on a substrate which affords protection for the eggs. Darters would choose the best site available (i.e., course vs. smooth substrate). The 3- to 6-m depth zone exhibits the coarsest sediment type in the study area (Winnell and Jude 1979). It is possible that this bottom affords johnny darters a suitable spawning area, therefore, spawning probably takes place there. After spawning, johnny darters move into deeper water (Scott and Crossman 1973). The majority of our fish (90) caught during June, July and August were trawled at 6- and 9-m contours (Fig. 50). During September and October, johnny darter densities increased with depth: 63% of the catch was collected at the 9- and 12-m bottom contour during September and 69% of the October catch was collected at the 12- and 15-m contours (Fig. 50). A preference by darters for the 12- and 15-m depths was exhibited during September and October 1977 and 1978. Johnny darter catches declined sharply during November and December. Nearly all fish caught (71%) were taken at the deepest stations (12 and 15 m) during November while all of the December catch was collected at 15 m (Fig. 50). It is suspected that johnny darters move out beyond 15 m during the November-April period with movement to deeper water being initiated in September. The violent physical conditions in the nearshore area (i.e., low temperature, strong wind, wave action and ice) could very likely be the reason for lower densities of johnny darters in the study area during this period. There is comparatively less physical stress on the nearshore area from mid-May to early September.

Seasonal distribution - Pigeon Lake--In contrast to Lake Michigan all johnny darters caught in Pigeon Lake (483) were collected in beach seine hauls, the only method of adult fish sampling employed in Pigeon Lake during 1979. A 48% increase in the catch of johnny darters occurred between 1978 and 1979 in Pigeon Lake. Gonad data suggest (Table 29) that spawning took place during May to mid-July 1979. Johnny darter larvae were also caught during May in Pigeon Lake (see FISH LARVAE AND FISH EGGS). This species spawned during April and May 1978 in Pigeon Lake. September was the month of maximum catch (137) (Fig. 51). These were mostly adult fish (35-65 mm); 111 were caught at Lake Michigan influenced station S and 26 from Pigeon Lake undisturbed station V. Sixty-seven percent of the Pigeon Lake catch was taken at night compared to 1978 when 64% was caught at night. Eighty-one percent of the johnny darters caught in Pigeon Lake were caught from water with a temperature range of 11 to 15 C (Fig. 52). During 1978, 88% of the catch was taken from water with a temperature range between 11 and 25 C; 11-19 C was the preferred temperature range in 1977. Size range of johnny darters caught in Pigeon Lake was 20-80 mm; 85% were between 45 and 65 mm.

Temperature-catch relationships--Johnny darters were collected at water temperatures from 0.3 to 17 C in Lake Michigan during 1979 (Fig. 53) and from 0.3 to 21.3 C during the period 1977-1979. This wide range of temperatures indicates that johnny darters do not migrate extensively to water of preferred temperature, but remain in a limited area and are caught over a broad range of temperatures. In Lake Michigan, data from this study are indicative of a seasonal depth preference as opposed to distributions according to temperature preference. Although many johnny darters are caught in Pigeon Lake when water temperatures range from 11 to 25 C, there can be no temperature preference

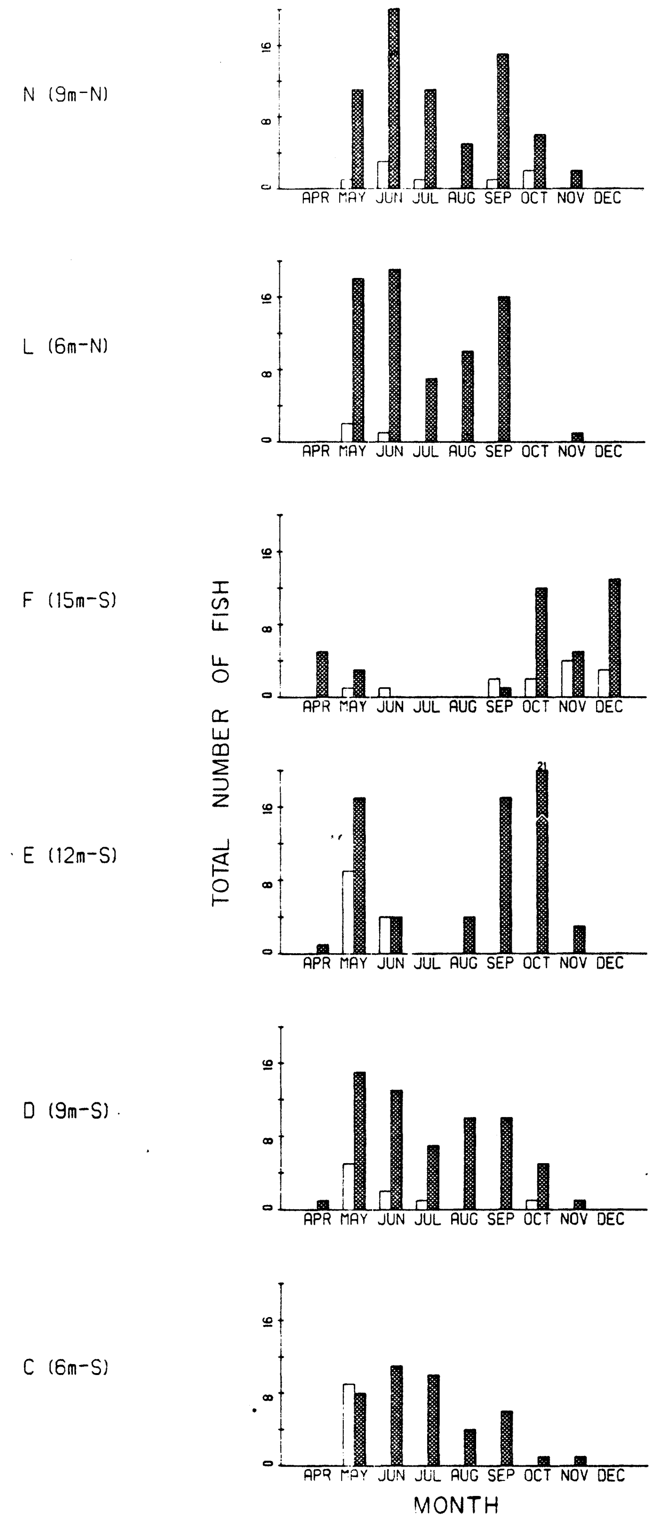


Fig. 50. Total number of johnny darters caught in duplicate trawl hauls during day and night once per month April to December 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. ☐ = day ■ = night * = no day sampling performed.

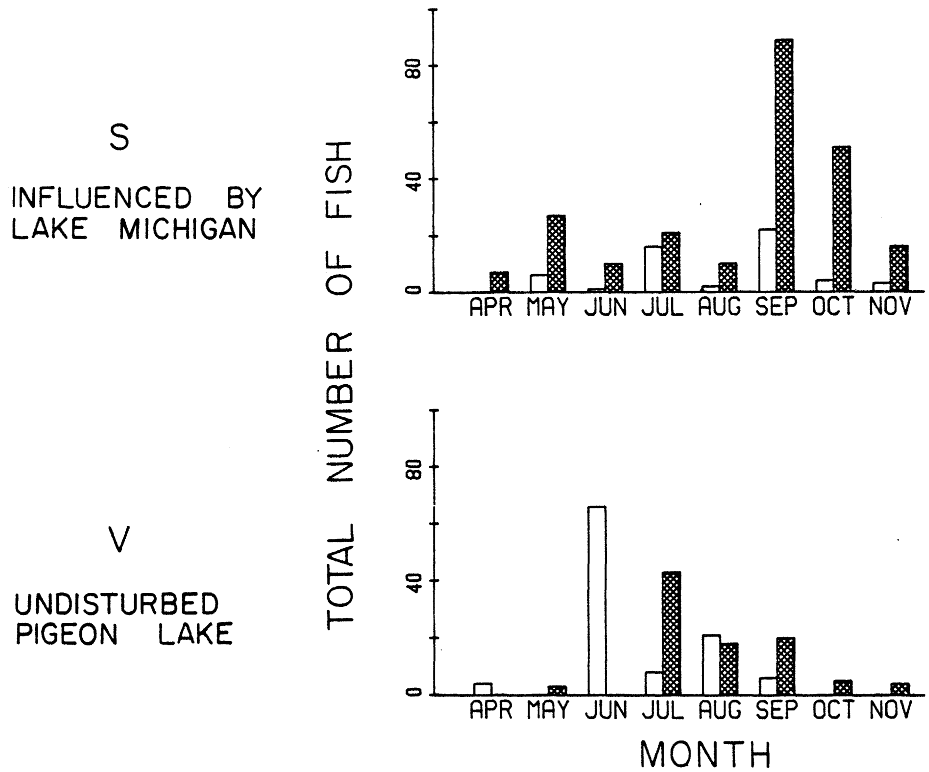


Fig. 51. Total number of johnny darters caught in duplicate seine hauls during day and night once per month April to November 1979 in Pigeon Lake near the J. H. Campbell Plant, eastern Lake Michigan. ☐ = day ■ = night.

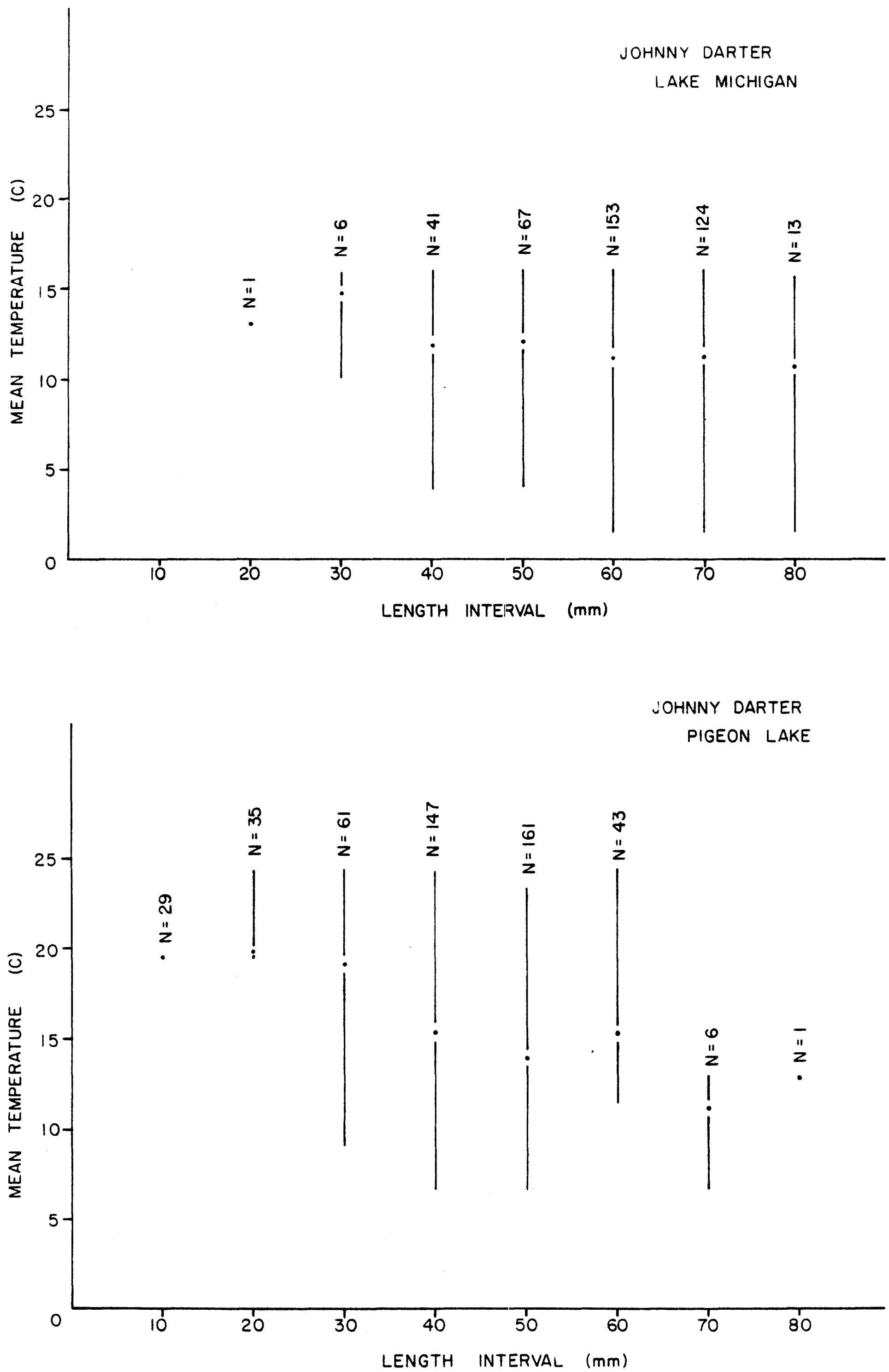


Fig. 52. Weighted mean temperatures at which various sizes (10-mm length groups) of johnny darters were collected by all gear types from Lake Michigan and Pigeon Lake near the J. H. Campbell Plant, eastern Lake Michigan, 1979. Vertical bars represent the range, N = number of fish.

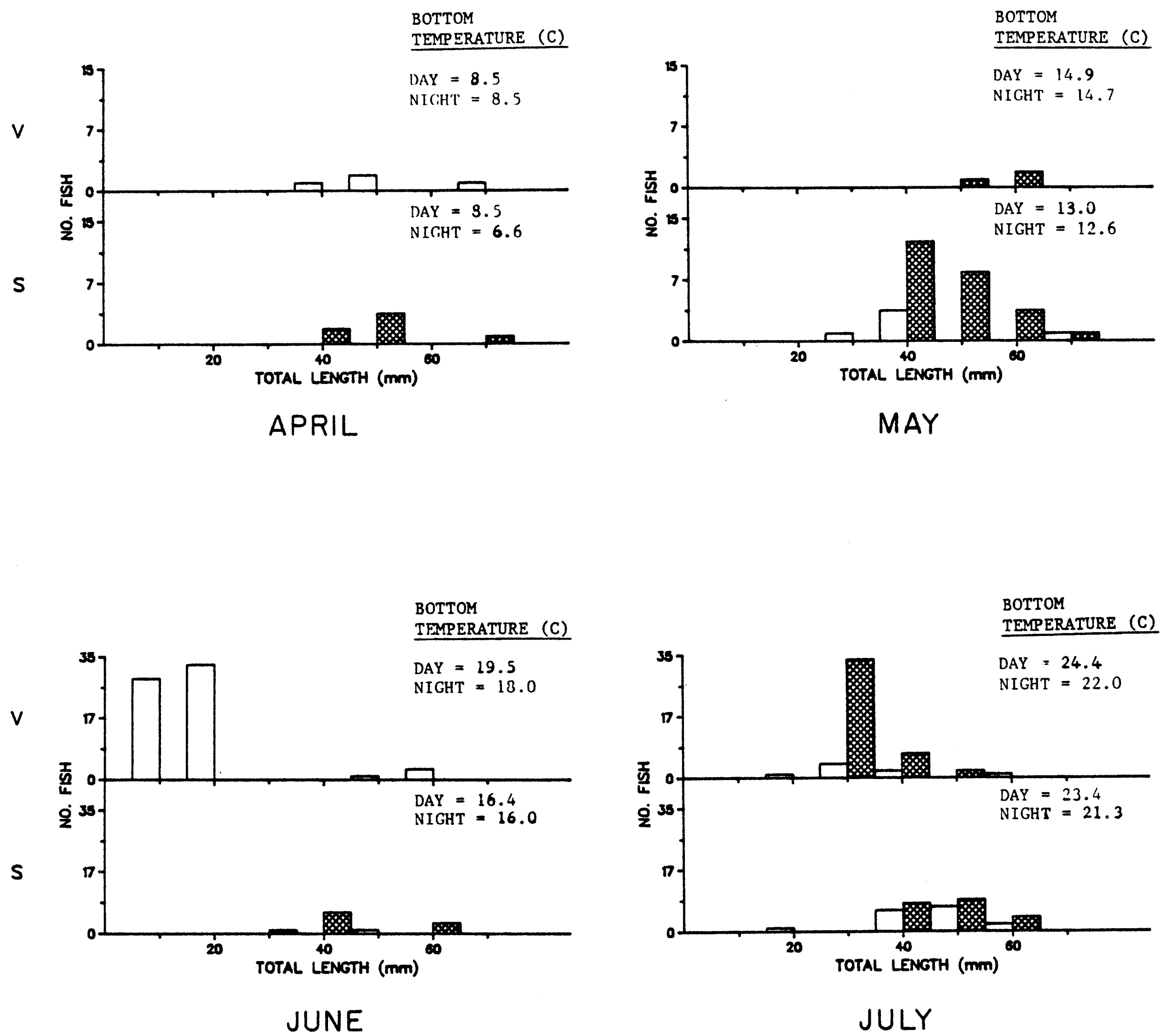


Fig. 53. Length-frequency histograms for johnny darters caught in duplicate seine hauls during April to November 1979 in Pigeon Lake near the J. H. Campbell Plant, eastern Lake Michigan. □= day ■= night.

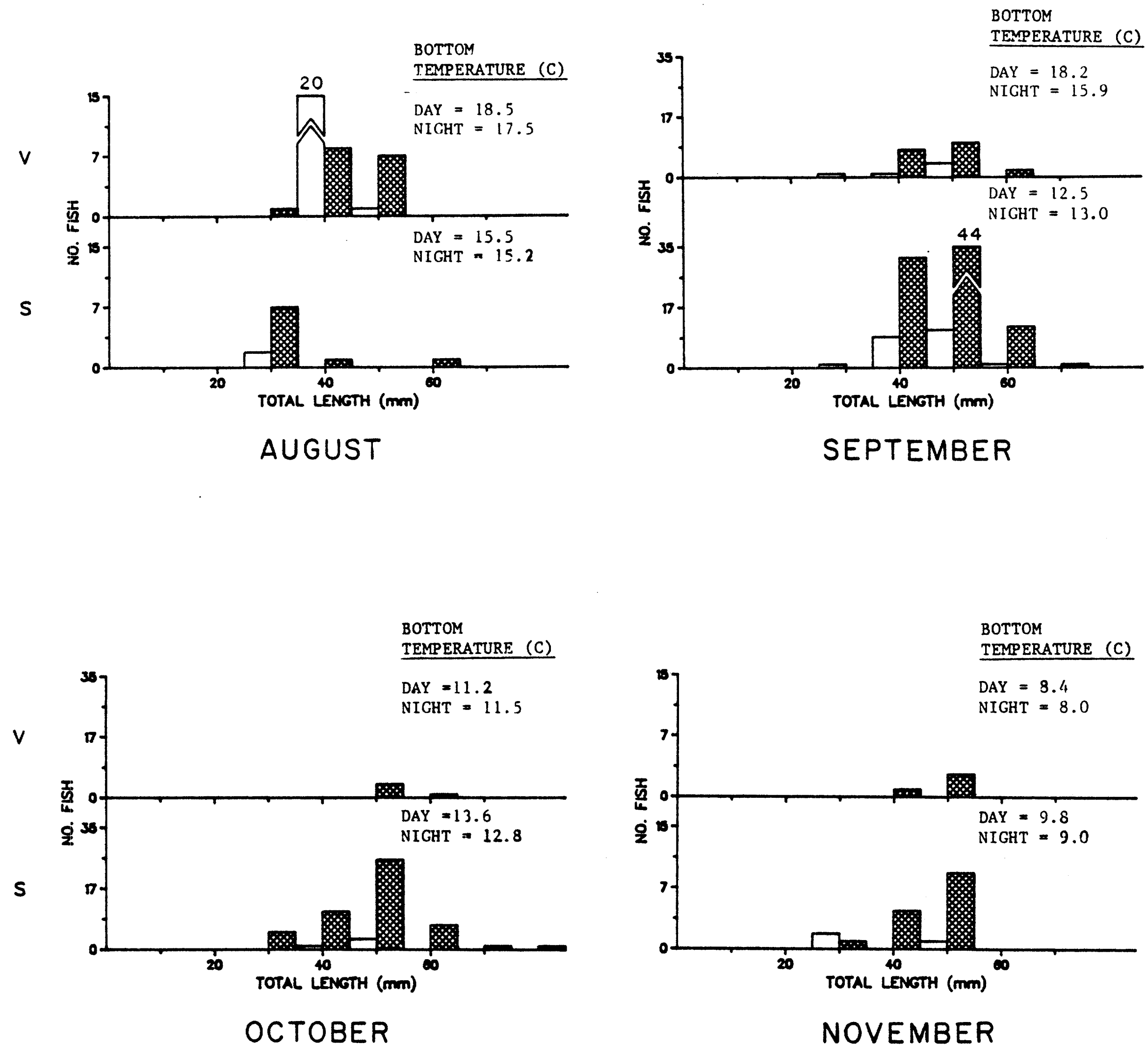


Fig. 53. Continued.

Table 28. Monthly gonad conditions of johnny darters caught during 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. All fish examined in a month were included except poorly received specimens.

	Gonad condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Slight development	3	10	1	1	8	37	19	3	6
	Mod. development	1	32	10	4	3			2	2
Males	Well developed			4	1					
	Ripe-running									
	Spent			1						
	Slight development		2	2	1		21	17	4	3
	Mod. development	3	36	4	2		1	2	8	
Females	Well developed		5	21	10	5				
	Ripe-running			12	4					
	Spent			3	2					
	Absorbing									
Immature			13	18	9	11	6	10	5	
Unable to distinguish			1	2	3	6	3	2		

established because of the limited number of stations (two). It is most likely that johnny darter abundance at these stations is more dependent on time of year rather than water temperature.

Plant impacts--No johnny darters were impinged during 1979 at the Campbell Plant. Although 27,400 johnny darter larvae were entrained, the Campbell Plant has apparently had little effect on the johnny darter populations of Lake Michigan and Pigeon Lake. Johnny darter catches increased nearly twofold in Pigeon Lake while declining slightly in Lake Michigan. The larvae that were entrained were most likely produced in the intake canal, thus their removal would probably not affect Pigeon Lake or Lake Michigan populations. SCUBA observations in the intake canal confirmed the presence of a large resident population of johnny darters.

Summary--Johnny darters spawned earlier in Pigeon Lake (April-June) than in Lake Michigan (May-August). This species was most susceptible to our sampling gear at night in Pigeon Lake and Lake Michigan. There appears to be a preference for depth or area as opposed to temperature in Pigeon Lake and Lake Michigan. In Lake Michigan, johnny darters move to water deeper than 15 m during the period November to April. A movement to shallower water begins in May in preparation for spawning.

Table 29. Monthly gonad conditions of johnny darters caught during 1979 in Pigeon Lake near the J. H. Campbell Plant, eastern Lake Michigan. All fish examined in a month were included except poorly received specimens.

	Gonad condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Males	Slight development	2	2		2	5	11	10	4	
	Mod. development		3	4	1		1	2		
	Well developed				2					
	Ripe-running				1					
	Spent		3							
Females	Slight development	2	1	2	1		10	13	7	
	Mod. development	4	4		1		2	5	2	
	Well developed		14	3	8			1		
	Ripe-running				1					
	Spent				1					
	Absorbing									
Immature		3	8	66	65	27	45	6	4	
Unable to distinguish			1	2		5	14	13	6	

Bluegill--

Introduction--Bluegill was the fourth-most numerous species captured in Pigeon Lake during 1979 (591 seined specimens) although the abundance of bluegills was substantially less than abundance of the three species which dominated Pigeon Lake samples (see ADULT AND JUVENILE FISH, Yellow Perch, Alewife and Spottail Shiner). Fewer bluegills were caught during previous sampling years (Jude et al. 1978, 1979a) compared with 1979; catches in all 3 yr were predominantly YOY. Relative lack of adult bluegills from samples collected between 1977 and 1979 is indicative either of gear avoidance or absence from the sampling areas. Pigeon Lake sampling stations influenced by the Pigeon River (sampled only in 1977) are thought to be preferred bluegill habitat in the area (Jude et al. 1979a). Lake residents who have been questioned have commented on the decline in bluegill populations which apparently were higher in earlier years.

Seasonal distribution--

April-July--No bluegills were captured in the early months of 1979. Since catches were comprised mainly of YOY, fish were not recruited to seines until August.

August--All 19 bluegills captured were 15-34 mm YOY seined at beach station V (undisturbed Pigeon Lake). Bluegills were caught in nearly equal numbers during day and night (Fig. 54).

September--Bluegill catch in September (467 fish) far surpassed catches during any other month. Again, all specimens were YOY (15-44 mm) seined at station V (undisturbed Pigeon Lake). Night seine catches (335) more than doubled day seine catches (132).

October--Ninety-seven bluegills (15-54 mm) were seined in October, again mostly at night. For the first time in 1979, bluegills (4) were seined at beach station S (influenced by Lake Michigan); the other 94 fish were captured at station V (undisturbed Pigeon Lake).

November--Only eight bluegills appeared in November seine hauls. Three fish were sampled at station S (influenced by Lake Michigan) and five at station V (undisturbed Pigeon Lake).

Temperature-catch relationships--Bluegills were caught in water ranging from 8.0 to 18.5 C. Temperatures most suitable for bluegill spawning occurred in July (Fig. 55) so appearance of YOY in August was predictable. Mean day-night water temperatures at station V (undisturbed Pigeon Lake) were consistently higher (by approximately 1-4 C) than temperatures at station S (influenced by Lake Michigan) from April through September. In October and November station S temperatures exceeded those of station V by about 1-2 C (Fig. 55). This temperature profile may partially explain the appearance of bluegills at station S during October and November because bluegills actively seek warmer temperatures in their environment (Snow et al. 1970). Orientation

to preferential temperatures by juvenile bluegills may be modified, however, by presence of adult bluegills exhibiting territorial behavior (Beitinger and Magnuson 1975).

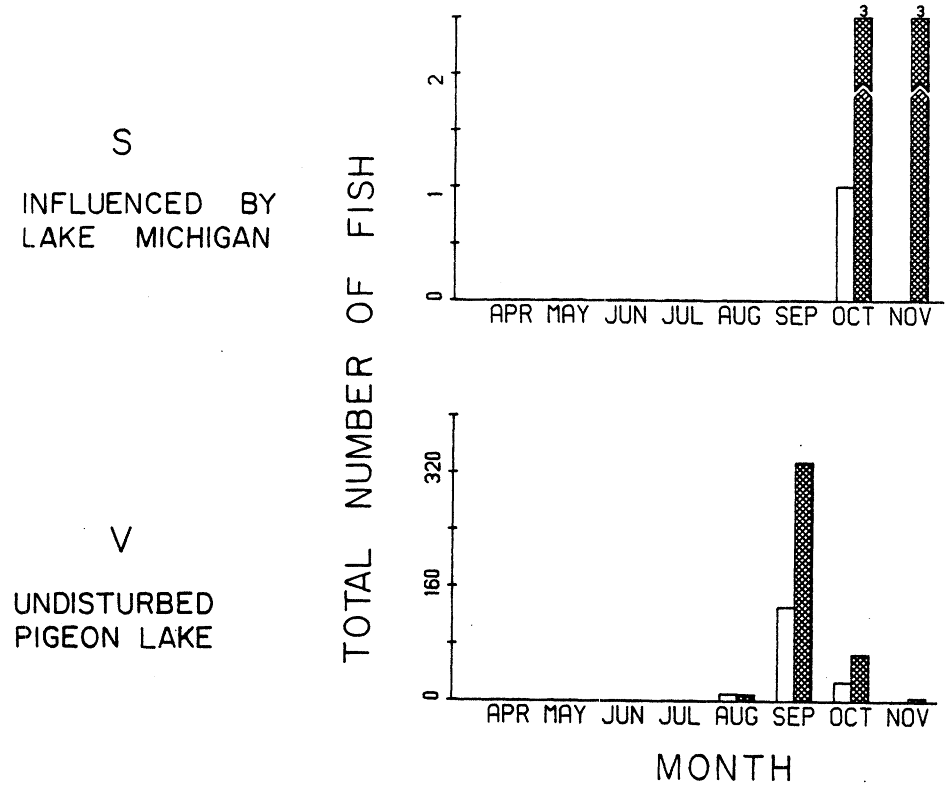


Fig. 54. Total number of bluegills caught in duplicate seine hauls during day and night once per month April to November 1979 in Pigeon Lake near the J. H. Campbell Plant, eastern Lake Michigan. □ = day ■ = night.

Other considerations--Recently hatched bluegills continuously occupy shallow water; older and larger fish reside mostly in deeper water during summer daylight hours (Snow et al. 1970). Larger bluegills migrate to shallow water in the evening and early morning to feed. Such behavior, along with increasing net avoidance with age, is reflected by the disproportional day-night catch of bluegills after fish reached about 2 mo of age. In total, 421 bluegills were caught in night seine hauls while 170 were caught during the day (Fig. 54).

Bluegills in 1979 samples ranged from 15 to 54 mm. All fish were immature.

Impingement--Bluegills were impinged in relatively small numbers mostly during fall and winter (January, October, November, December). Greatest estimated numbers of impinged bluegills occurred in October (71) and November (45). Except for an estimated five fish impinged in April, no other bluegills were found in spring or summer impingement samples. Size range of impinged bluegills (47-104 mm) coupled with their apparent seasonal susceptibility to

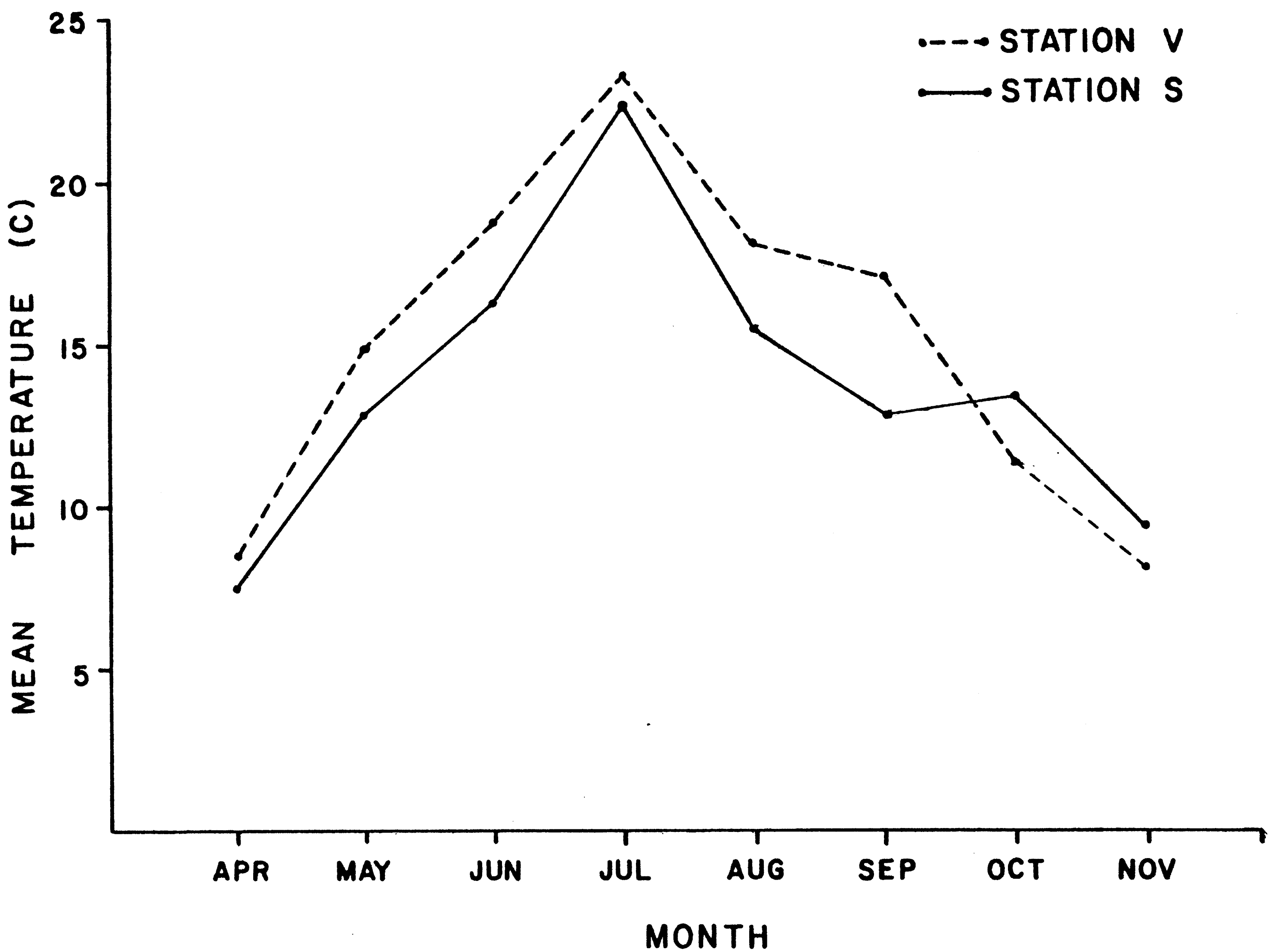


Fig. 55. Mean day-night water temperatures measured during monthly seine sampling at beach station S (influenced by Lake Michigan) and beach station V (undisturbed Pigeon Lake) during April to November 1979 in Pigeon Lake near the J. H. Campbell Plant, eastern Lake Michigan.

impingement, implies that bluegills are subject to impingement almost exclusively during their first 9 mo of life. Estimated numbers of impinged bluegills were fairly consistent between 1978 (183) (Jude et al. 1979a) and 1979 (145). An unknown proportion of impinged bluegills possibly originate from the discharge canal. Bluegills have been observed in the discharge canal and impingement of other species is known to be augmented from populations inhabiting this area (see ADULT AND JUVENILE FISH - Gizzard Shad).

Plant impacts--During 1979, 145 bluegills were impinged at the Campbell Plant. Unidentified *Lepomis* larvae were entrained in July (11,600) and August (74,500). Many of these were probably bluegills. Those bluegills lost to entrainment and impingement probably represent a small proportion of Pigeon Lake bluegill populations. Prime bluegill habitat is found at beach station V (undisturbed Pigeon Lake) and former beach station T (influenced by Pigeon River), areas out of the influence of the general flow of cooling water drawn into the plant.

Summary--Though no adult bluegills were caught during the 1979 sampling season, spawning success was indicated by appearance of YOY in August. Due to relatively cool water temperatures in Pigeon Lake, bluegill spawning may have intensified during July rather than being dispersed over several months (late spring to early autumn). The relatively large number of YOY bluegills (concentrated in August and September) caught in 1979 compared with 1977 and 1978 implies particularly successful reproduction in 1979. Tendency to migrate daily from shallow to deep water appeared to characterize behavior of YOY bluegills between 2- and 3-mo old. Some YOY also appeared to actively seek warmer temperatures in October and November by dispersing to beach station S (influenced by Lake Michigan). Impingement of bluegills was consistent between 1978 and 1979 and is not felt to be a threat to the Pigeon Lake bluegill population. In general, bluegills appear to be most vulnerable to impingement during their first 9 mo of life.

White Sucker--

Introduction--White sucker was the seventh-most abundant species collected in Lake Michigan during 1979 with 413 individuals taken (Table 13), as compared to 294 caught in 1977 and 319 white suckers caught in 1978. Twenty-two white suckers were collected in Pigeon Lake in 1979.

Seasonal distribution--

April--No white suckers were collected during April in Lake Michigan or Pigeon Lake in 1979. April is the major spawning time for white suckers in Lake Michigan, so absence of white suckers from Lake Michigan may reflect their presence in streams for spawning.

May--Forty-seven white suckers were collected in May in Lake Michigan; all were taken in bottom gill nets (Fig. 56). One, probably a yearling (90 mm), was seined in Pigeon Lake at night at beach station S (influenced by Lake Michigan). Highest catches occurred in Lake Michigan at stations C (6 m,

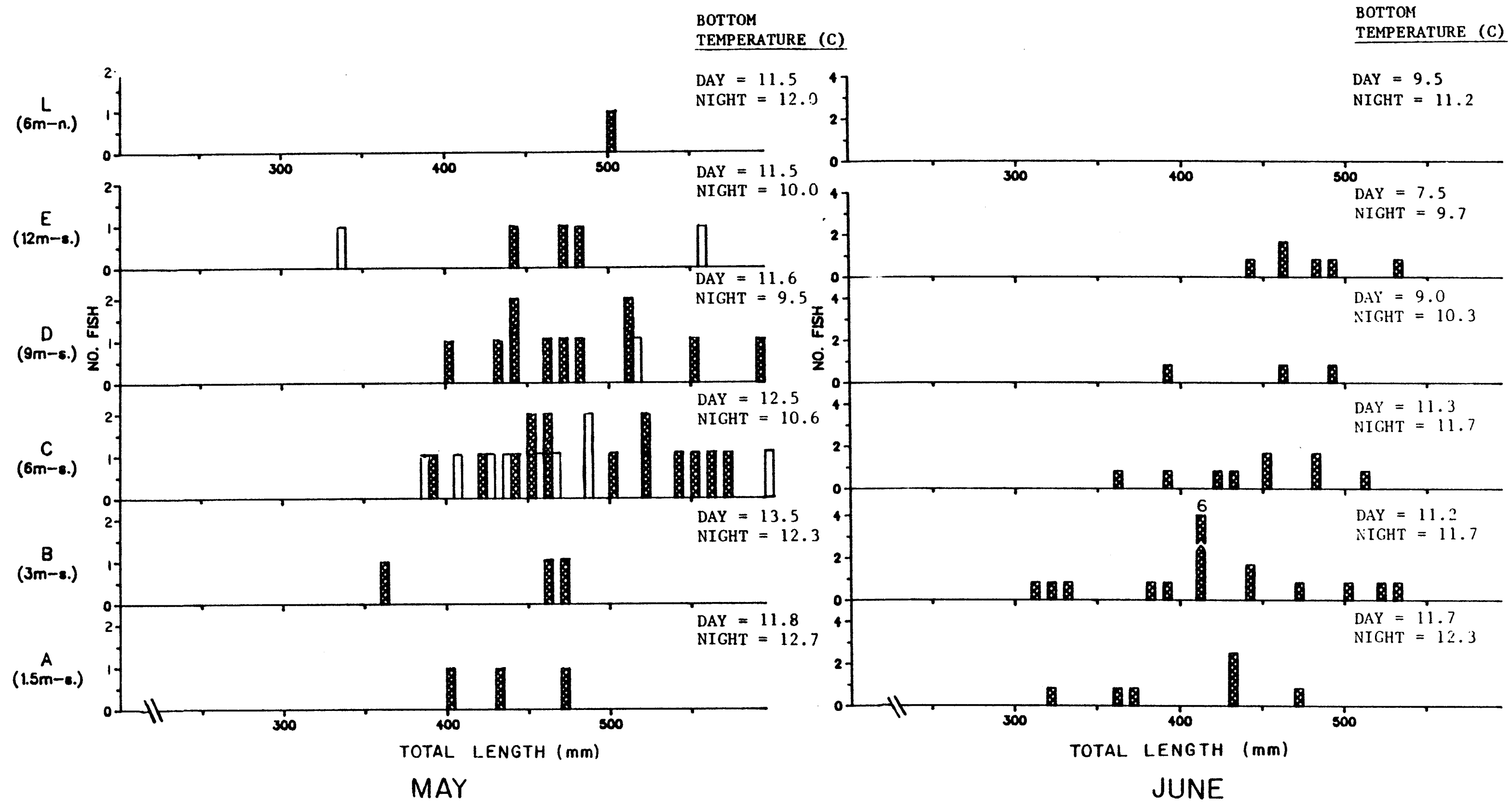


Fig. 56. Length-frequency histograms for white suckers caught in duplicate bottom gill nets during April-November 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. □ = day ■ = night + = no sampling performed.

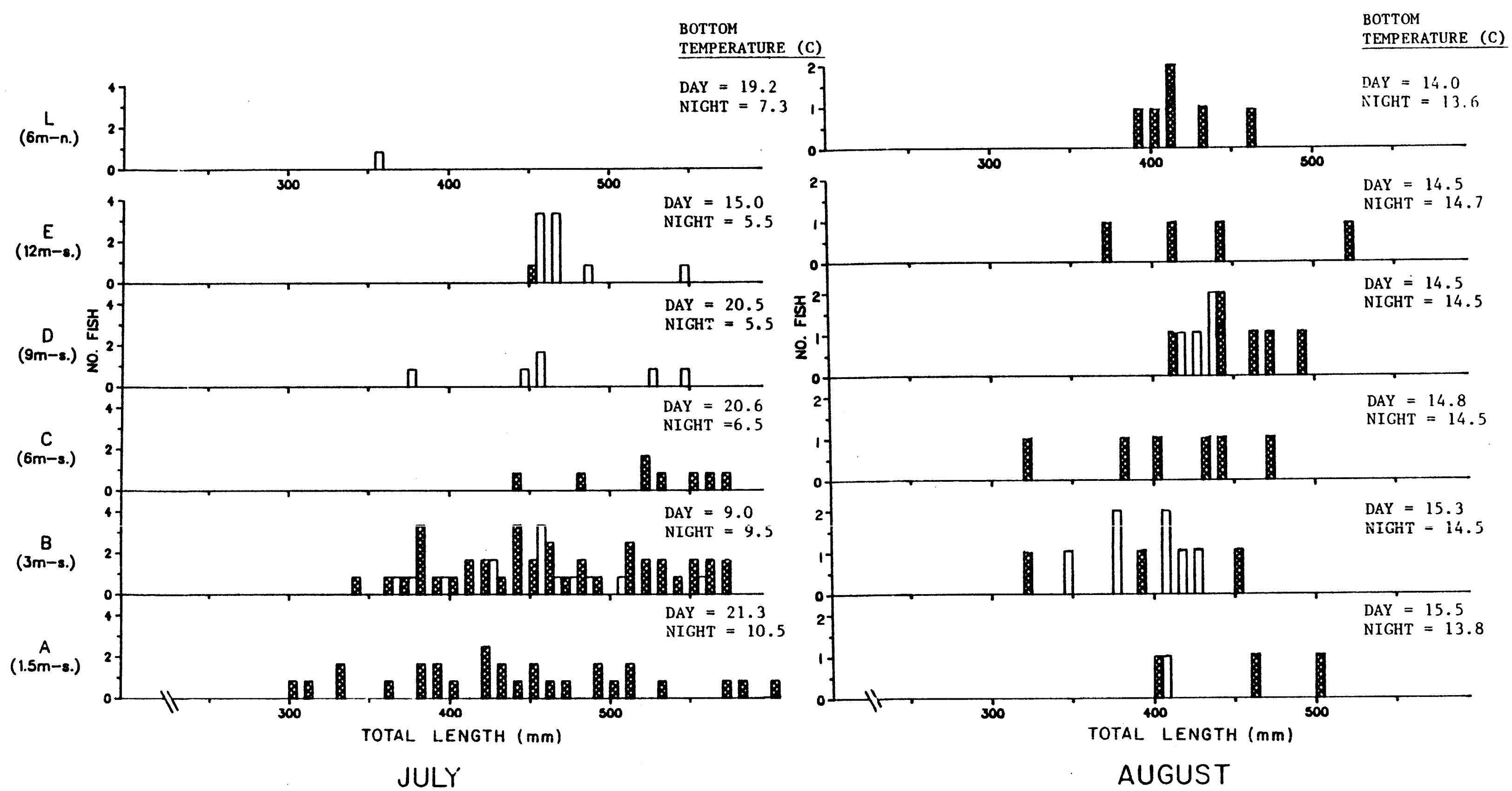


Fig. 56. Continued.

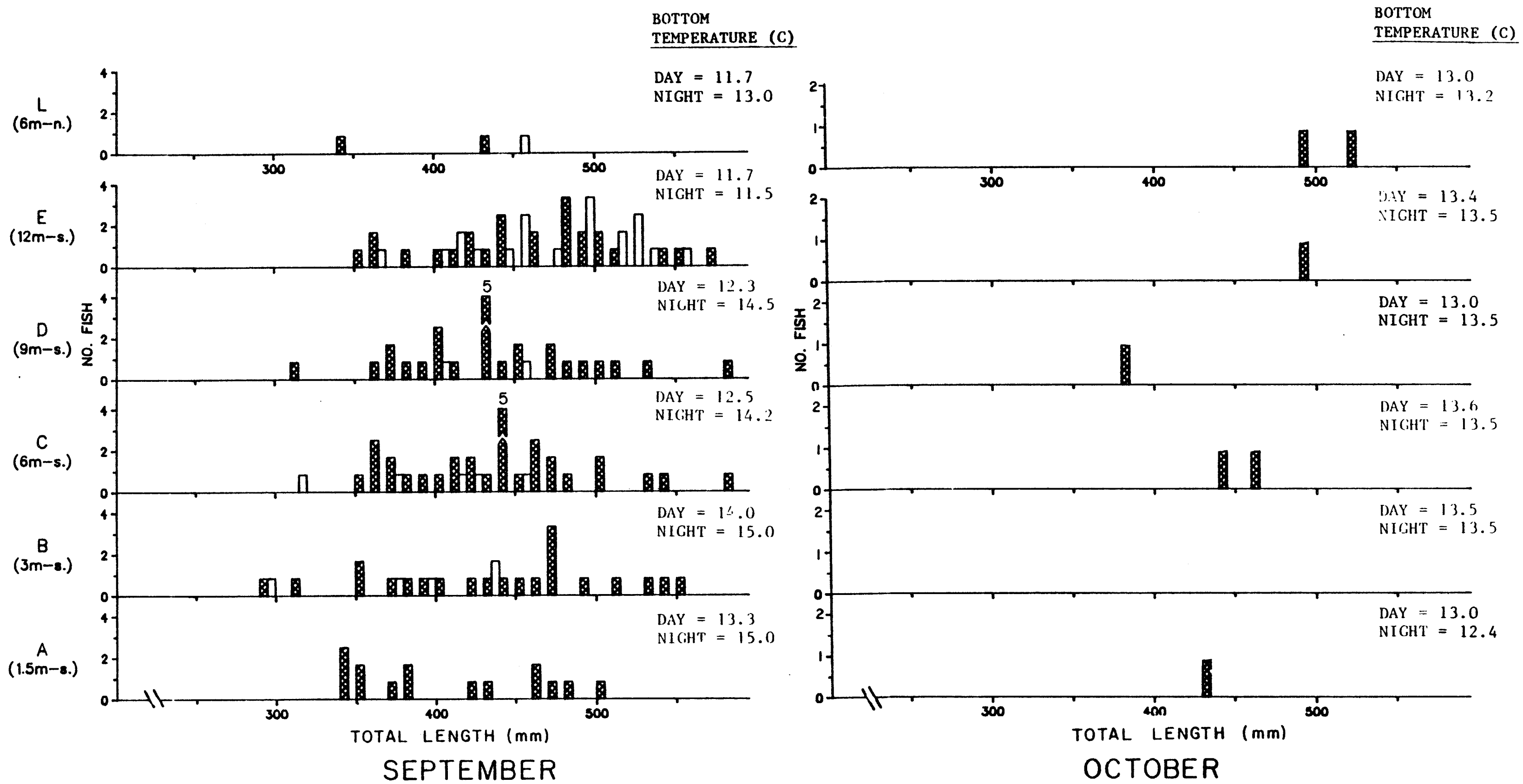


Fig. 56. Continued.

south) and D (9 m, south) (23 and 12 individuals, respectively). Over 74% of the white suckers were collected at night. Water temperatures at time of collection ranged from 9.5 to 15 C.

By May, fish with spent gonads were observed (Table 30). However, no ripe-running fish were collected during the entire year and only a few were found to have well developed gonads. These observations suggest that spawning migrations had occurred prior to the beginning of our sampling and that absence of white suckers in early samples was due to their presence in streams.

Table 30. Monthly gonad conditions of white suckers caught during 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. All fish examined in a month were included except poorly received specimens.

	Gonad condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Slight development		13	13	36	9	22			
	Mod. development		5		6	9	47	3	1	
Males	Well developed		1				7	3		
	Ripe-running									
	Spent		4	2	9					
	Slight development		9	21	9	6	26		1	
	Mod. development			2	8	8	41			
Females	Well developed				1	1	13	1		
	Ripe-running									
	Spent		13	2	8	5				
	Absorbing		2		36	4	1			
Immature										
Unable to distinguish				2			1	2		

June--During June, 42 white suckers were collected, all in bottom gill nets and all at night. Station B (3 m, south) had the largest catch, 17 suckers (Fig 56). Water temperatures for all stations yielding suckers ranged from 9.7 to 12.3 C. Two adult white suckers were seined at night in Pigeon Lake at beach station V (undisturbed Pigeon Lake).

July--July catches of white suckers were the second highest for the year with 113 taken in Lake Michigan and 17 in Pigeon Lake. Of those caught in Lake Michigan, 70% were caught at night when water temperatures at all bottom gill net stations ranged from 5.5 to 10.6 C due to an upwelling that occurred after day nets had been set. Two white suckers were also taken in night

surface gill nets, one each at stations C (6 m, south) and L (6 m, north) where temperatures were 8.5 and 10.0 C, respectively. One was seined at night at beach station R (north discharge). Station B (3 m, south) day bottom gill nets had the highest catch of suckers (14). These nets were set 1 day after the other day nets due to weather problems and hence, temperatures reflected the influence of an upwelling (9.0 C). Other day temperatures at gill net stations ranged from 15.0 to 21.3 C. White suckers appeared to be responding to temperature as they moved inshore with cooler, upwelled water.

August--Fewer white suckers (42) were caught in August than in July, possibly reflecting the somewhat higher water temperatures present at all Lake Michigan stations (12.1-15.5 C). Two white suckers were taken in trawls, one each at stations F (15 m, south) and N (9 m, north). The rest were caught in bottom gill nets. None were taken in seines or surface gill nets.

September--Catch of white suckers was highest for the entire year in September. Lake Michigan sampling collected 158 fish; 2 were seined in Pigeon Lake (Fig. 57). Bottom gill nets accounted for all but two white suckers, which were taken in night trawls at stations B (3 m, south) and D (9 m, south). Night gill net sets accounted for 78% of gill net collections. Water temperatures were similar to those in August, ranging from 11.5 to 15.0 C, so temperature does not appear to be the reason for movement of white suckers into our sampling area.

Relatively large catches of white suckers during late summer and early fall were also noted in 1977 and 1978 in the vicinity of the Campbell Plant (Jude et al. 1978, 1979a). White suckers may possibly reside in nearshore areas of Lake Michigan during summer and fall following their return from streams after spawning. In late fall, they appeared to move farther offshore, as numbers of fish caught by our sampling gear declined drastically.

October--White suckers appeared to have moved out of our sampling area in October. Only seven fish were collected, all in night bottom gill nets. Water temperatures, ranging from 12.4 to 13.5 C, were not extremely different from temperatures in September, thereby eliminating temperature as a reason for movement from the area. This movement from our sampling area in October, also noted in 1977 and 1978 (Jude et al. 1978, 1979a), may be a movement to deeper water as a response to the approach of late fall and winter. No white suckers were collected in Pigeon Lake this month.

November--Only four white suckers were collected this month, all in night bottom gill nets, three at station C (6 m, south) and one at L (6 m, north). Water temperatures were 7.2 C and 6.9 C, respectively. No white suckers were collected in Pigeon Lake. White suckers had apparently moved out of the area. None was collected in December trawls.

<u>Temperature-catch relationships</u>--Water temperatures in Lake Michigan recorded when white suckers were collected ranged from 5.5 C to 21.3 C (Appendix 1). Over 94% of white suckers were taken at temperatures from 8 to 16 C. White suckers appeared to prefer cooler temperatures as was evidenced by their concurrent appearance with an upwelling in July. However,

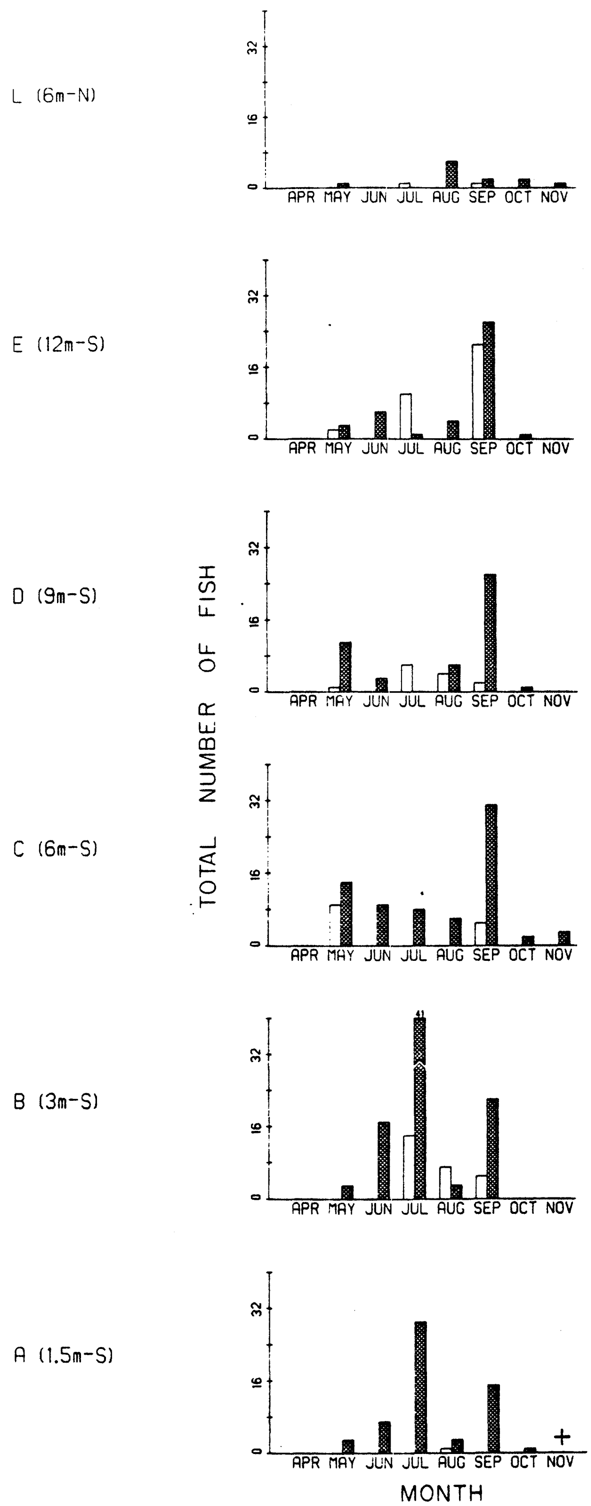


Fig. 57. Total number of white suckers caught in duplicate bottom gill nets fished during day and night once per month April to November 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. ☐ = day ■ = night + = no sampling performed.

temperature did not appear to be an overriding factor in their distribution as numbers of fish collected declined in fall with no appreciable change in temperature regimes in the study area.

Impingement--Twenty-nine white suckers were collected in impingement samples at the Campbell Plant. Twenty-five of the 29 collected were taken in March and April. These fish had probably moved into Pigeon Lake to spawn upstream in the Pigeon River, but instead moved into the intake canal and were subsequently impinged. Expanding this number to a total estimated number impinged over the entire year results in 215 white suckers impinged in 1979.

Plant impacts--Comparing 1979 impingement losses of white suckers to populations present in the study area, we feel the loss of 215 suckers represents a small impact on the white sucker population. Sucker larvae were entrained at the Campbell Plant during April and May (1656 and 17,455, respectively), however, the relatively low number of white suckers that were collected in Pigeon Lake in 1979 as well as in 1978 and 1977 (Jude et al. 1978, 1979a) suggests that the Pigeon River is not a major spawning area for white suckers and therefore, the Campbell Plant represents little threat to the Lake Michigan white sucker population.

Other considerations--In 1979, no YOY or immature white suckers were collected, except for one yearling in May in Pigeon Lake. In July and August 1978, 49 YOY white suckers were collected in beach seines. Only one YOY was collected in 1977. Pigeon River does not appear to have a major spawning run of white suckers in spring and, therefore, a lack of YOY is not unexpected.

Summary--White suckers were collected during every month sampled except April and December. They were most abundant in Lake Michigan during late summer and early fall and were collected from the beach zone to 15 m. Most (98.3%) were collected in bottom gill nets.

Bluntnose Minnow--

Introduction--Previous study (1977-1978) of the bluntnose minnow in Pigeon Lake near the Campbell Plant documented the preference of this species for the areas in Pigeon Lake either influenced by Pigeon River or the undisturbed areas of Pigeon Lake. Areas influenced by inflowing Lake Michigan water typically exhibited lower abundance of this species. With few notable exceptions, this trend was also observed during our 1979 sampling, as 329 bluntnose minnows were caught at station V (undisturbed Pigeon Lake), compared with 94 bluntnose minnows caught at station S (influenced by Lake Michigan). Study of this species in Pigeon Lake during 1977-1979 documented its importance as a food item for northern pike.

Seasonal distribution--

April--Initial sampling during April 1979 yielded only four bluntnose minnows; all were seined at station S (influenced by Lake Michigan). Their absence from samples taken at station V (undisturbed Pigeon Lake) in April 1979 is in stark contrast with April 1978 when bluntnose minnow were abundant

in the area. The decreased occurrence of bluntnose minnows at station V in April 1979 compared with April 1978 is thought to be related to temperatures. In April 1979 water temperatures during sampling (average day-night temperature 8.5 C) were 2.3 C warmer than those of April 1978 (average day-night temperature 10.8 C).

May--Highest catch of bluntnose minnows at station S (influenced by Lake Michigan) in 1979, as in 1978, occurred in May (Fig. 58). It is probable that this species moves into the shallow area near station S during May to spawn. Data from 1978 suggested that spawning occurs in May, initiated by water temperatures of 11-17 C which includes the temperatures recorded for station S during May. Although the area near station V (undisturbed Pigeon Lake) would appear to be a more suitable spawning habitat with many submerged trees and objects under which bluntnose minnows could spawn, relatively few bluntnose minnows were caught there during May 1979 (Fig. 58). Temperatures at station V were also within the 11-17 C temperature range, indicating that water temperature was not a constraint on spawning. Gonad data from 1979 give no clear indications of spawning time, as we were unable to determine gonad condition on many specimens. This species is particularly susceptible to rapid deterioration upon freezing.

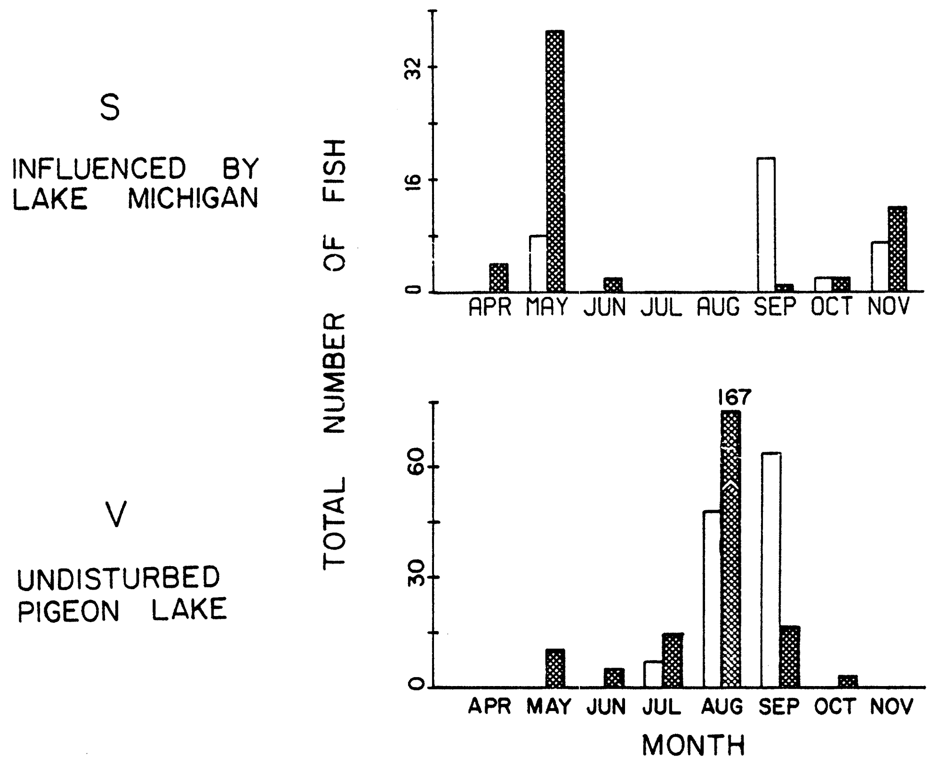


Fig. 58. Total number of bluntnose minnows caught in duplicate seine hauls during day and night once per month April to November in Pigeon Lake near the J. H. Campbell Plant, eastern Lake Michigan. □ = day ■ = night.

June, July--Seines in June 1979 yielded six bluntnose minnows (two from station S and four from station V). July sampling during 1979 also showed low occurrence of bluntnose minnows at seinable depths (none caught at station S and 20 caught at station V). Such low occurrences of bluntnose minnows in the shallows of Pigeon Lake, particularly near station V (undisturbed Pigeon Lake) during June and July of 1979, contrast sharply with our observations during 1977-1978. During those years, in excess of 50 bluntnose minnows were caught during both June and July sampling at station V (undisturbed Pigeon Lake). The reason for the decreased occurrence of bluntnose minnows at station V during June and July 1979 compared with 1977-1978 is unknown. Water temperatures between years are fairly comparable, and no definite trend of abundance with temperature was evident.

August--August marked the first major catch of bluntnose minnows at station V (undisturbed Pigeon Lake) (Fig.58). Many of those bluntnose minnows caught in August were probably YOY which corresponded closely with the occurrence of this age-group of fish in 1977-1978. It is probable that YOY bluntnose remain in the shallows of Pigeon Lake throughout their first summer of life, being recruited to the sampled population in August due to their increased size. Coincident with the abundant catch of YOY bluntnose minnows in August at station V, was the absence of bluntnose minnows from seine hauls at station S (influenced by Lake Michigan).

September--During September bluntnose minnows were still present near station V (undisturbed Pigeon Lake), although fewer (80) were caught compared with August (215 caught). Occurrence of 20 bluntnose minnows in seine hauls at station S (influenced by Lake Michigan) during September suggests that individuals of this species occasionally disperse to Lake Michigan-influenced areas of Pigeon Lake in spite of colder temperatures (in comparison with station V). Thus, 1979 data did not support the hypothesis, suggested by 1978 data, that dispersal of bluntnose minnows was related to temperature similarity between the two Pigeon Lake stations. Only two bluntnose minnows were caught at station V (undisturbed Pigeon Lake) during October-November 1979, indicating that the majority of bluntnose minnows had moved to the deeper sections of Pigeon Lake (Fig. 58). This movement to deeper water during autumn months is also suggested by the dearth of specimens caught at station S (influenced by Lake Michigan) in October (Fig. 58). However, the 19 bluntnose minnows caught there in November indicate that there is some occasional movement of bluntnose minnows into the shallows during autumn months.

October--The only occurrence of bluntnose minnows in Lake Michigan during 1979 was observed in October when three individuals were seined at station P (south reference). This single occurrence confirms the contention that this species rarely moves into Lake Michigan as was also observed in 1978.

Impingement--No bluntnose minnows were observed in impingement samples during 1979, confirming former conclusions that this species only rarely gets impinged. The tendency of this minnow to inhabit slow moving water, as well as its demersal behavior is probably responsible for its low impingement rate.

<u>Plant impacts</u>--Impingement as well as entrainment data indicate that the impact of the Campbell Plant on the bluntnose minnow population in Pigeon Lake was probably negligible. This species was rarely impinged, and due to its habit of spawning in well protected areas in slow moving sections of streams; entrainment of larvae was minimal.

<u>Summary</u>--Bluntnose minnow was the sixth-most abundant species caught in Pigeon Lake. As was found during 1977-1978, the habitat near beach station V (undisturbed Pigeon Lake) was preferred over station S (influenced by Lake Michigan). Data from 1979 did not support the contention that occurrences of bluntnose minnows at station S were temperature related. Bluntnose minnows were not observed in impingement samples during 1979, but 1978 data suggest that they are occasionally impinged.

<u>Minor Species</u>

Ninespine Stickleback--

Our sampling during 1977-1979 indicated that ninespine sticklebacks are seasonally abundant at depths to 15 m in Lake Michigan near the Campbell Plant. They first become prominent at these depths during May, and exhibit an offshore migration to depths greater than 15 m in July or August. We are unsure of spawning sites in the vicinity of the plant, however, Pigeon Lake was undoubtedly the site for some ninespine stickleback spawning during April-May 1978. Sampling in Pigeon Lake gave no indication that this area was used as a spawning site during 1979 as only nine sticklebacks were caught there from April to June, none exhibiting advanced gonadal development.

As during 1978, trawling during April 1979 produced few ninespine sticklebacks, indicating that a shoreward migration to depths of 15 m or less in Lake Michigan had not yet occurred. The first indication of this shoreward migration during 1979 occurred during May when sticklebacks were trawled at depths 3-15 m (Fig. 59). Water temperatures at times of capture in May were 9-12 C. Gonad data gave some indication that some spawning had taken place (Table 31) as one ripe-running female stickleback was found. The majority of specimens caught during May, however, did not exhibit advanced gonadal development.

The onset of a major spawning peak for ninespine sticklebacks was indicated by collections during June. At this time, the vast majority of sticklebacks caught exhibited advanced gonad development (Table 31) while nine were spent. Sticklebacks tended to be more common at depths 9-15 m than 3 and 6 m in June. Temperatures at times of collection in June ranged from 14.8 to 16.0 C.

In spite of an upwelling of cold water during July which reduced water temperature to 4.0-7.3 C, sticklebacks surpassed the abundance observed in June at depths 9-15 m. Again, as during June, notably fewer sticklebacks were found at the shallower (3 and 6 m) depths in July compared with 9-15 m (Fig. 59). Spawning of sticklebacks was continuing at this time as indicated by gonad data (Table 31).

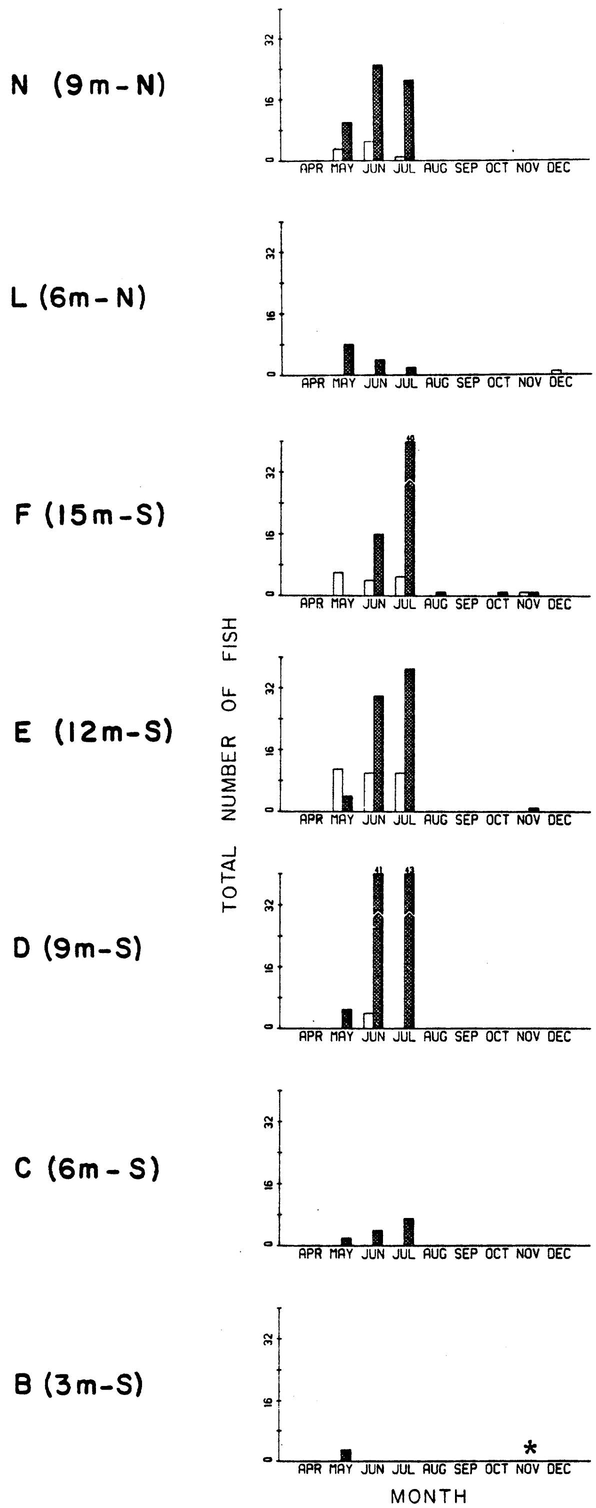


Fig. 59. Total number of ninespine sticklebacks caught in duplicate trawl hauls during day and night once per month April to December 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. □ = day ■ = night * = no day sampling performed.

Table 31. Monthly gonad conditions of ninespine sticklebacks caught during 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. All fish examined in a month were included except poorly received specimens.

	Gonad condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Slight development	1	13		2				1	
	Mod. development		7	8	4				1	
Males	Well developed			4	1					
	Ripe-running									
	Spent		1		7					
	Slight development	1	5	1						1
	Mod. development		20	7	2					
Females	Well developed		5	69	36					
	Ripe-running		1	21	33					
	Spent			9	18					
	Absorbing				3					
Immature			2	3	9	1		1		
Unable to distinguish			1	6	1				1	

In contrast with what was observed in 1978, when the offshore migration (depth greater than 15 m) of sticklebacks occurred in September, an earlier (August) offshore migration was observed in 1979. The one stickleback trawled was taken at station F (15 m, south) and gave indication that offshore migration of sticklebacks to deeper water (>15 m) had occurred.

Impingement of ninespine sticklebacks decreased significantly during 1979 (estimated 90 impinged) compared with 1978 impingement (an estimated 310 impinged). Although the reasons for this are speculative, it may be that this phenomenon is another indication that sticklebacks did not migrate into Pigeon Lake to spawn during spring 1979 to the extent observed during spring 1978. Greatest impingement during 1978 and 1979 occurred during the spawning season.

Lake Trout--

During 1979, 222 lake trout were collected in Lake Michigan; none were collected in Pigeon Lake. Lake trout were collected in all months sampled, April to December. Five lake trout were collected in impingement samples taken at the Campbell Plant during 1979. Sizes of lake trout collected in Lake Michigan ranged from 118 to 887 mm with 82% greater than 455 mm.

In April, nine lake trout were caught, all in bottom gill nets and most at depths of 6 m and less. Three yearling (127-143 mm) and 10 adult lake trout were caught in May. Most (8) were caught in night bottom gill nets. Thirteen lake trout were caught in June, five yearlings (135-175 mm) and eight adults. All were taken at night; adults were caught in bottom and surface gill nets and yearlings were collected in trawls.

During July sampling, an upwelling occurred which lowered temperatures in our study area by 10-15 C (Appendixes 1, 2 and 3). Lake trout moved into the area in response to lowered water temperatures; 22 were caught this month, all after the upwelling had occurred. Five were yearlings and were collected in trawls; the rest were adults caught in bottom and surface gill nets.

In August, 13 adult lake trout were caught, all in night bottom gill nets. All were caught at depths of 12 m and less with the largest catch at station A (1.5 m, south). This shallow water station had the coolest temperatures available at this time (13.8 C).

Twenty-seven lake trout were caught in September; three were yearlings (178-212 mm) caught in trawls. Largest catch of adult lake trout (9) was at night in bottom gill nets at station A (1.5 m, south). Most lake trout (23) were caught at depths of 6 m and less. Gonad data (Table 32) showed that the majority of lake trout examined had well developed gonads.

Lake trout spawn in the fall. Historically, lake trout were known to spawn primarily on rocky bars where eggs were indiscriminately cast among the rocks (Daly et al. 1969). Since the near-extinction of lake trout in Lake Michigan by overfishing and sea lampreys, lake trout populations have been re-established and maintained by stocking. Movement of lake trout inshore to shallow water as spawning time approaches is believed to be an artifact of stocking and not characteristic of original lake trout populations (Rybicki and Keller 1978). As lake trout "home" to areas of stocking, they spawn in unsuitable habitat over unsuitable substrate, i.e., inshore, sandy areas subject to wave action, sedimentation and ice accumulation. Therefore, the large catches of lake trout we typically see in fall are indeed due to spawning migrations, however, somewhat misdirected.

October was the peak month for lake trout catches when 87, all adults, were collected. Largest catches of lake trout were at depths of 6 m and less. Examination of lake trout gonads (Table 32) showed many fish with well developed and ripe-running gonads.

In 1978, lake trout were collected in Pigeon Lake during October (Jude et al. 1979a). In 1979, none were collected in Pigeon Lake, probably due to elimination of bottom gill net sets at station M (influenced by Lake Michigan). Five lake trout were collected in impingement samples, a yearling in May and one adult each in September, October, November and December. These data suggest that some lake trout do enter Pigeon Lake. The total estimated number of lake trout lost to impingement during 1979 was 25 fish. This number probably does not represent a threat to lake trout populations. Most of these

fish were impinged in fall during spawning migrations inshore. Field sampling indicated relatively large numbers of lake trout were in the study area during this time compared to numbers of lake trout impinged.

Table 32. Monthly gonad conditions of lake trout caught during 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. All fish examined in a month were included except poorly received specimens.

	Gonad condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Slight development	1	2	1	1	1	1	1	4	
	Mod. development	5	3	3	4	5	6	36	5	
Males	Well developed				2		5	16	6	
	Ripe-running							3		
	Spent								8	
	Slight development	2	3		3	1		3	4	
	Mod. development	1	1	4	3	6		2		
Females	Well developed				4		12	25	3	
	Ripe-running							1	4	
	Spent								1	
	Absorbing		1							
Immature			3	5	5		3		1	1
Unable to distinguish									1	

November sampling resulted in the collection of 37 lake trout; all but one (210 mm) were adults. Twenty-nine of 37 were caught at north transect stations. No obvious water temperature differences were seen between north and south transect stations; however, the higher catch is clearly related to the riprap being laid at that time for the new Unit 3 intake and discharge structures. Spawning lake trout were attracted to these rocky areas more than the sandy substrate of the south transect. Some ripe-running as well as some spent individuals were seen in November (Table 32) suggesting that spawning was declining.

In December, only trawling was performed. One lake trout was collected, a 267-mm juvenile fish at station F (15 m, south). Lake trout had moved out of the study area into deeper water for winter.

Examination of lake trout for evidence of sea lamprey attacks showed that of 181 fish examined, 24% had lamprey scars or wounds (Table 33). This percentage compares with a 36% lamprey scarring rate in 1978 (Jude et al. 1979a) and 27% in 1977 (Jude et al. 1978). Other investigators have reported

scarring rates of 25% in Indiana waters of Lake Michigan (McComish and Miller 1975) and 22% near the D. C. Cook Plant (Jude et al. 1979b). Occurrence of fresh lamprey wounds on lake trout declined this year from the 15% seen in 1978. In 1979, only two fish had fresh lamprey wounds.

Table 33. Occurrence of sea lamprey scars on lake trout caught near the J. H. Campbell Plant, eastern Lake Michigan, 1979.

Length Interval (mm)	Total Number Examined	Number Scarred	Percent Scarred	No. scars per fish			
				1	2	3	4
850-900	3	2	67	1	1		
800-849	4	1	25	1			
750-799	29	16	55	9	5	2	
700-749	41	12	29	11	1		
650-699	51	10	20	7	2		1
600-649	30	1	3	1			
550-599	16	2	12	2			
500-549	2	0					
450-499							
400-449							
350-399							
300-349							
250-299	1	0					
200-249							
150-199	1	0					
100-149	1	0					
TOTAL	181	44	24	32	9	2	1

Temperature is an important factor influencing lake trout distributions. All lake trout collected were caught at water temperatures of 15.3 C or less. Presence of lake trout throughout our entire sampling season reflects the cooler temperatures prevalent in our study area in 1979 (Fig. 19).

Lake trout are important predators in Lake Michigan. Examination of lake trout stomachs showed alewives were the most predominant prey item in their diet. Smelt were also a common food item. Other species seen in lake trout stomachs were gizzard shad, spottail shiners, trout-perch, unidentified cyprinids and centrarchids, and *Mysis relicta*. As in 1978, most lake trout collected during October and November did not have food in their stomachs.

Sampling in spring and summer of 1980 resulted in the collection of 60 lake trout fry (22-62 mm total length). These fry represent the first evidence of natural reproduction by planted lake trout in southern Lake Michigan (Jude et al., unpublished manuscript). The newly laid rock riprap covering Unit 3 intake and discharge structures provided ideal spawning substrate for

lake trout during the 1979 fall spawning season. Lake trout eggs spawned during this time incubated over winter and probably hatched in late February 1980.

Longnose Sucker--

Introduction--Adult fish data collected during 1977 and 1978 indicated that the longnose sucker is a common species in the study area. During 1979, 221 longnose suckers were collected, of which 208 were taken in Lake Michigan and 13 in Pigeon Lake.

Seasonal distribution--No longnose suckers were caught during April 1979 and only two specimens occurred in April 1978 samples. Low catches of longnose suckers in the inshore water during early spring were also observed near the Cook Plant, southeastern Lake Michigan in 1973 and 1974 (Jude et al. 1979b). Longnose suckers move into tributary streams to spawn mostly during April-June (Brown and Graham 1954; Harris 1962; Geen et al. 1966; Dryer 1966). Scarcity of longnose suckers in the inshore water at the Campbell Plant during April was believed to be due to stream residence for spawning. Some sucker spawning may take place in Pigeon Lake or Pigeon River. A supplementary gill net set in the channel connecting Pigeon Lake to Lake Michigan on 19 March 1979 captured an adult longnose sucker which appeared to be moving into Pigeon Lake. During February 1980, an adult white sucker was caught in a bottom gill net set near the entrance of Pigeon River into Pigeon Lake. There was, however, no evidence of a major sucker run in Pigeon Lake or Pigeon River. Adult longnose suckers have never been caught in Pigeon Lake during scheduled sampling in spring during 1977-1979. Larval suckers were rarely found in Pigeon Lake or entrainment samples during this period. Most longnose suckers probably spawned outside the study area.

Forty longnose suckers, all adults, were caught in Lake Michigan during May. At night, longnose suckers were distributed from 1.5 to 12 m, being most common at 9 m (Fig. 60). Longnose suckers were only caught from 6 to 12 m during the day. Increase of longnose sucker catches in May compared with April levels may be due to return of longnose suckers to the lake after their spawning in streams. Most specimens collected in May were spent or had slight gonad development (Table 34) indicating that spawning had occurred prior to the sampling period. A similar increase in longnose sucker catches was observed in the study area during May 1978 (Jude et al. 1979a). Longnose suckers were also reported to spawn in shallow areas of lakes (Scott and Crossman 1973). A ripe-running male and a male with well developed gonads also occurred in May samples suggesting that some spawning may take place in Lake Michigan near the Campbell Plant.

During June, only 14 longnose suckers were collected, all at night. Of these, 13 were taken from 3 to 9 m and 1 was seined at beach station R (north discharge). Most longnose suckers collected showed slight and moderate gonad development (Table 34) suggesting that spawning in the vicinity of the study area ended in June. Reasons for the decline of longnose sucker catches in June are not known. Water temperatures on the sampling day, 19 June, ranged from 9.5 to 12.5 C and were comparable to those observed during the May

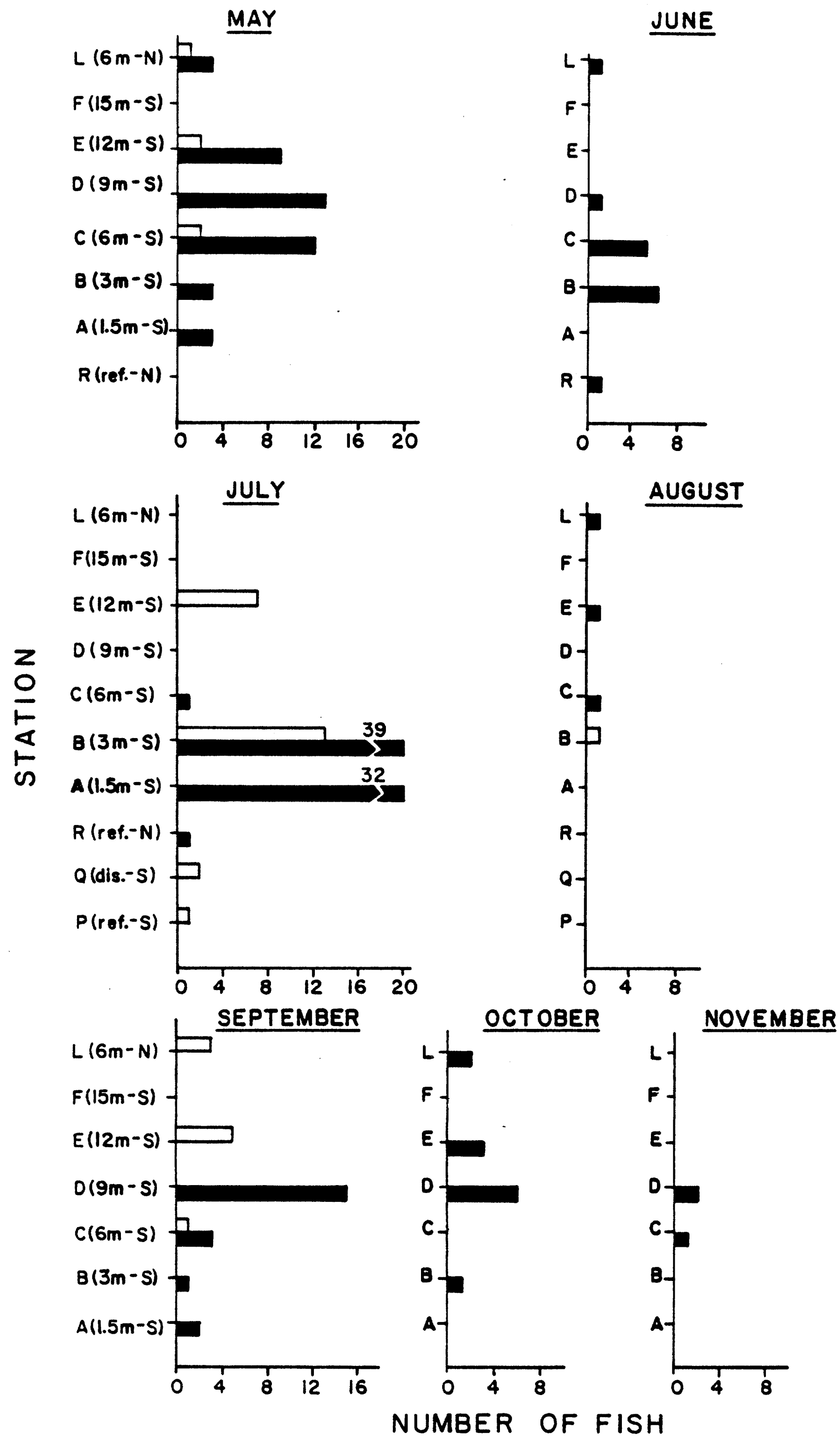


Fig. 60. Total number of longnose suckers caught during day and night once per month from April to December, 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan.

sampling period (Appendix 1). Inshore water, however, appeared to warm up rapidly during this period with bottom temperatures ranging from 14.2 to 17.2 C on 21 June (Appendix 3).

Table 34. Monthly gonad conditions of longnose suckers caught during 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. All fish examined in a month were included except poorly received specimens.

	Gonad condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Slight development		12	7	22		3	1	1	
	Mod. development		11	1	7	1	6		1	
Males	Well developed		1			1	1	6		
	Ripe-running		1							
	Spent		11		27					
	Slight development		4		1		1			
	Mod. development		3	2	9	1	11	1	1	
Females	Well developed						7	3		
	Ripe-running									
	Spent		3	1	5					
	Absorbing		2		22		1	1		
Immature				2	3	1				
Unable to distinguish				1	1					

Catches of longnose suckers peaked in July with 97 specimens collected. At night, they were found mostly at 1.5 and 3 m. Small numbers of longnose suckers also occurred in night seines at beach station R (north discharge) and in night gill nets at 6 m (Fig. 60). During the day, longnose suckers were caught in small numbers at 3, 6 and 9 m. A few immature individuals were also collected in day seines at beach station P (south reference) and station Q (south discharge). Large catches of longnose suckers on 17 July coincided with the cooling of inshore water due to an upwelling. Bottom temperatures in the study area on the above date ranged from 5.5 to 10 C. Similar movements of longnose sucker to inshore water during an upwelling were also reported in southeastern Lake Michigan (Jude et al. 1979b).

Only four longnose suckers were collected during August, one at 3 m, two at 6 m and one at 12 m. Decline of longnose sucker catches in August may be due to warming of inshore water during summer. Bottom temperatures during the August sampling period (13.6-15.5 C) were slightly higher than the temperature range (5-13 C) at which the majority of longnose suckers were collected in 1977 and 1978.

The number of suckers collected rose to 30 in September. They were caught from 1.5 to 9 m at night and from 6 to 12 m during the day. Reasons for increased longnose sucker catches in September are not known. Water temperatures were approximately the same as those observed in August (Appendix 1). Only 12 longnose suckers were caught in October and 3 in November. This catch decline probably resulted from offshore movement of longnose suckers. In Lake Superior, Dryer (1966) found most longnose suckers in water 18-53 m in the fall.

Longnose suckers were caught in shallow and deep water at night, but tended to be restricted to deep water during the day (Fig. 60). As was found during 1977 and 1978, more longnose suckers were caught at night (169) than during the day (39).

Temperature-catch relationships--During 1979 longnose suckers were caught between 7 and 19 C. Longnose suckers tended to prefer cool water, being found mostly in water at temperatures of 6-15 C during the period 1977-1979. This preference for cool water was probably the main factor determining the unusual abundance of longnose suckers in catches during July 1979. Relatively high catches of longnose suckers in July 1977 (16) were probably due to an upwelling of cool water with temperatures ranging mostly from 6 to 11 C. Responses of longnose suckers to water temperature, however, appeared to vary considerably. Substantial numbers of longnose suckers were sometimes caught at relatively high temperatures as was found during July 1978 when 16 longnose suckers were collected at temperatures of 15.5-17 C.

Other considerations--Longnose suckers collected in 1979 ranged from 37 to 620 mm. In Lake Superior longnose suckers grow to a size of 81 mm at the end of the first year of life and 137 mm at the end of the second year of life (Bailey 1969). Based on the above data, the two 37-mm longnose suckers collected in June and July and three specimens 55-64 mm caught in Lake Michigan during July were probably YOY. Two other immature longnose suckers, 83 and 159 mm, collected in August and September, respectively, were probably yearlings. As was found in 1977 and 1978, most longnose suckers collected in 1979 were larger individuals ranging from 390 to 620 mm. Large longnose suckers probably avoided seines and trawls. Bottom gill nets accounted for the bulk of longnose sucker catches in Lake Michigan (198 of 208). Only five specimens were caught in seines and five in trawls. YOY and yearling longnose suckers were scarce in the study area. Seine catches included four YOY, 37-64 mm, collected during June and July and a 268-mm adult caught in July. Of the five trawled longnose suckers, one was a YOY (37 mm) collected at station B (3 m, south), one was a yearling and three were adults. No YOY or yearlings occurred in 1977 samples. Smaller longnose suckers collected in 1978 included only four yearlings 80-110 mm. Geen et al. (1966) reported that longnose sucker larvae drifted downstream toward the lake 1-2 wk after hatching. In Pyramid Lake, Alberta beach seining captured several YOY longnose suckers in June and July (Rawson and Elsey 1950). Occurrence of YOY longnose suckers in 1979 suggested that the shallow areas of Lake Michigan near the Campbell Plant may be used as nursery areas by this species.

All 13 longnose suckers collected in Pigeon Lake were YOY (40-60 mm) seined at beach station S (influenced by Lake Michigan) during July. These YOY may have drifted from Pigeon River where, as has been previously discussed, some sucker spawning probably took place. A larval sucker was collected at beach station S during May. These data suggested that longnose suckers may use Pigeon Lake as a nursery ground.

Approximately the same numbers of longnose suckers were collected in the study area from June to December in 1977 (33) as during the same period in 1978 (40). In 1979 longnose sucker catches from Lake Michigan and Pigeon Lake (221) were substantially higher than total 1978 catches (73). This increase was in part due to the occurrence of 18 YOY in Pigeon Lake and Lake Michigan in 1979. No YOY longnose suckers were caught in 1978. The major portion of the 1979 increase in sucker catch resulted from higher catches of longnose suckers 390-540 mm. Growth of larger longnose suckers was very slow, averaging only 20-25 mm a year (Harris 1962). Based on age-length data reported by Carlander (1969), longnose suckers 390-540 mm were probably 6- to 12-yr old. Individuals of approximately the same age-groups also made up the bulk of 1977 and 1978 catches (Fig. 61). Since longnose suckers start to spawn at approximately 5 yr (Geen et al. 1966; Bailey 1969), most large individuals collected were probably mature. Increase of longnose sucker catches may be related to more favorable environmental conditions for spawning in the vicinity of the study area in 1979 than during the previous 2 yr.

During 1977 and 1978, more longnose suckers were caught at reference station C (6 m, south) than at station L (6 m, north). This trend appeared to continue as 26 and 11 longnose suckers were caught at station C and station L respectively in 1979.

<u>Plant impacts</u>--Low numbers of longnose suckers were impinged during 1978. One longnose sucker, a 90-mm yearling, was collected from the traveling screens during 1979 resulting in an estimated total for the year of three. None were found in entrainment samples. Some of the unidentified sucker larvae collected in entrainment samples (19,100 estimated entrained during 1979) were probably longnose sucker larvae (see FISH LARVAE AND FISH EGGS - Unidentified Catostomidae).

Slimy Sculpin--

The slimy sculpin is common in Lake Michigan near the Campbell Plant, inhabiting inshore water (less than 15 m) during winter and early spring months. Our study during 1977-1978 suggests that the distribution of this species in Lake Michigan near the Campbell Plant is strongly influenced by water temperature. Wells (1968) reported that slimy sculpins were most frequently trawled at water temperatures of 4-5 C. This species was rarely caught in our study area at water temperatures exceeding 15 C, and most were caught at water temperatures less than 10 C. All slimy sculpins caught during 1979 were captured in Lake Michigan, however this species' occasional presence in impingement samples indicates slimy sculpins do enter Pigeon Lake. Ecologically this species plays an important part as prey for salmonids particularly during early spring months. Specimens collected during 1978 were

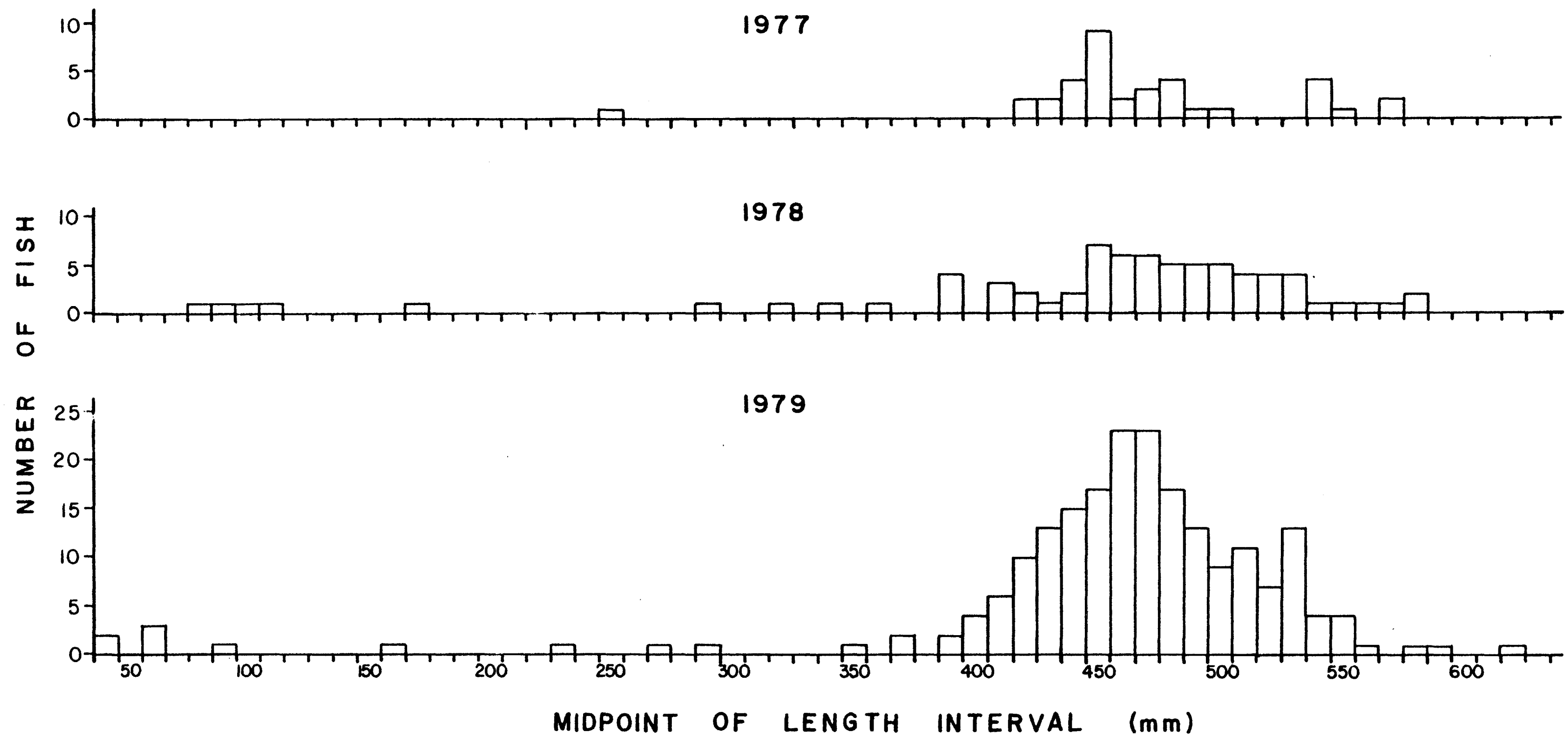


Fig. 61. Length-frequency histograms for longnose suckers caught in 1977, 1978 and 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan.

reported to have an extremely high (93%) infection rate of the parasitic acanthocephalan, Leptorhynchoides thecatus (Heufelder and Schneeberger 1980), however individual fish seemed unaffected by their presence.

As during 1978, initial sampling during 1979 commenced in April and trawl hauls indicated that slimy sculpins were generally distributed at depths 6-15 m (Fig. 62). Absence of slimy sculpins from the 3-m depth was noted not only during this month, but from May to November as well. Water temperatures at times of capture during April ranged from 1.5 to 3.0 C. Although the vast majority of slimy sculpins sampled during April-December were trawled, two were caught in other gear types (one in a seine and one in a bottom gill net) during April. Gonad data for slimy sculpins caught in April 1979 (Table 35) showed slight differences from April 1978 in that a lower percentage of slimy sculpins caught during April 1979 had well developed gonads, and none were ripe-running. This suggests the possibility of a later date of initial spawning during 1979. The increased percentage of well developed, ripe-running and spent female sculpins caught during May 1979 indicated that spawning primarily occurred in May during 1979, closely agreeing with the peak spawning time observed for this species in 1978. During May 1979 the majority of slimy sculpins caught were trawled at 9-15 m (Fig. 62) at water temperatures of 9-11.5 C.

From June to November during 1979, slimy sculpins were rarely caught at depths of 15 m and less near the Campbell Plant. This concurs with what we found during 1977-1978 when sporadic occurrences of slimy sculpins during these months were usually associated with coldwater upwellings.

With colder water temperatures in December, slimy sculpins were again common at depths of 9-15 m (Fig. 62). Water temperatures at this time were 4-5 C in the areas these fish were caught. Data presented by Wells (1968) suggest the bulk of the slimy sculpin population does not inhabit depths less than 18 m at any time during the year. It is likely, however, that during winter months under ice cover, this species distributes more uniformly by depth (compared with summer months) due to the more isothermal nature of the lake.

Greater catch of slimy sculpins in night collections (Fig. 62), compared with day collections, was observed during all 3 yr of sampling. Although the reasons for this are unclear, aquarium observations and SCUBA observations (Dorr and Miller 1975; Dorr and Jude 1980) of this species suggest that during daylight hours, slimy sculpins seek areas of cover as a negative phototaxic response. Also noted was the ability of this species to bury itself in sand when no cover was provided. Thus, small daytime catches might be related in part to this behavioral response to daytime light intensities.

Temperature-catch relationship data for slimy sculpins caught during 1979 (Fig. 63) agreed closely with data collected in 1977-1978 and showed a tendency of smaller slimy sculpins to be caught at higher water temperatures. Part of this trend is explained by the fact that smaller fish are only present

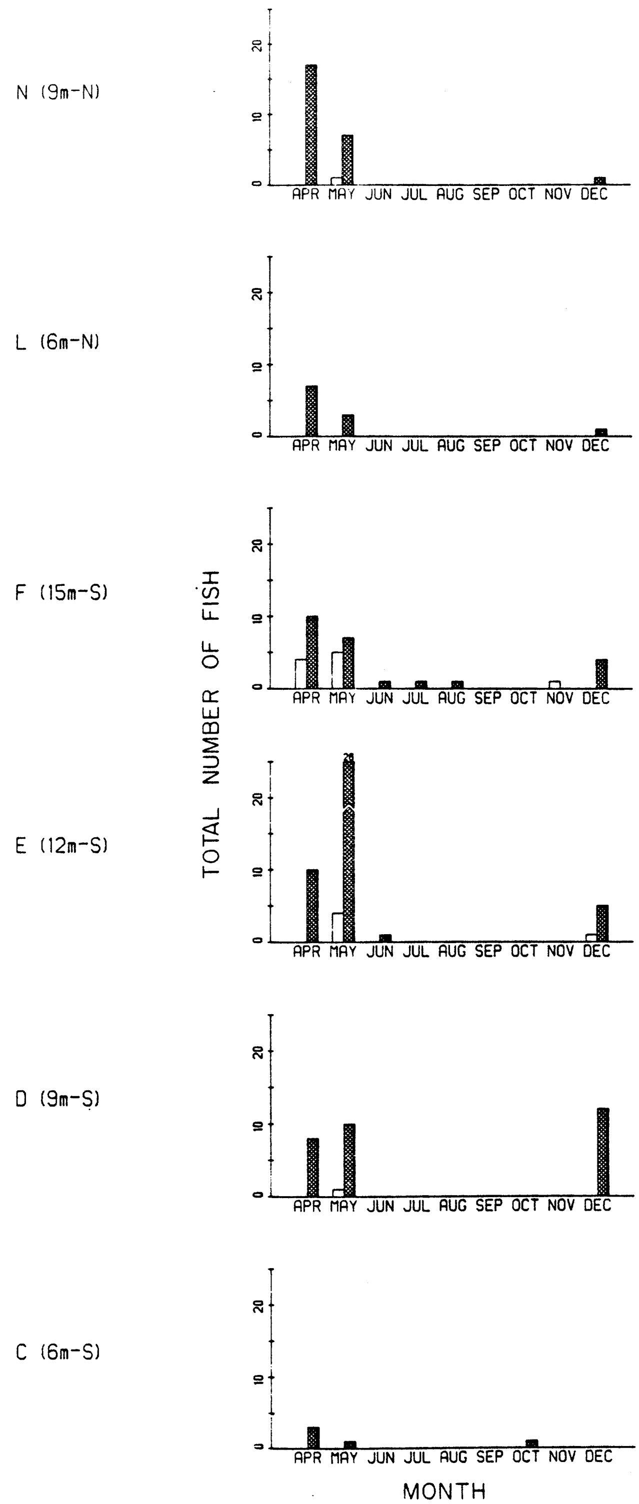


Fig. 62. Total number of slimy sculpins caught in duplicate trawl hauls during day and night once per month April to December in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. ☐ = day ■ = night.

Table 35. Monthly gonad conditions of slimy sculpins caught during 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. All fish examined in a month were included except poorly received specimens.

	Gonad condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Slight development	2	2					1	1	1
	Mod. development	32	31	1						19
Males	Well developed	4	3							
	Ripe-running									
	Spent		1							
	Slight development		3							2
	Mod. development	8								1
Females	Well developed	14	12							1
	Ripe-running		4							
	Spent		8							
	Absorbing									
Immature		1	1	1	1	1				
Unable to distinguish										

when water temperatures are warmer. We believe that the smaller slimy sculpins are more tolerant of warmer water and have less of a tendency to migrate to colder offshore water during late spring and summer months.

Impingement of slimy sculpins at the Campbell Plant increased slightly during 1979 (an estimated 100 fish impinged) compared with 1978 (estimated 66 fish impinged). The majority of the impingement during both years occurred during April, and was possibly related to prespawning dispersal activity of this species. Low rates of impingement during the colder winter months were observed during 1978-1979 and could be expected due to the increased abundance of this species in the inshore areas during these months. No impingement of this species was observed from May to October during 1979 owing to their offshore distribution in Lake Michigan.

Emerald Shiner--

Emerald shiners were once extremely abundant in Lake Michigan, but during the 1960s the population declined (Smith 1970). This decline has been attributed to competition from alewives since their population rose sharply during the 1960s and coincided with collapse of the emerald shiner population. Alewives and emerald shiners are probably competing for food and space (Jude et al. 1979a). Both species feed on zooplankton. Larvae and adults of both

species inhabit inshore areas at similar times of the year and both species spawn in early summer. Alewives have had a significant effect on emerald shiner populations in Lake Michigan; today small populations of emerald shiners in the lake may just be strays from tributary streams and lakes (Jude et al. 1979a). A comparison of catch data for the Cook and Campbell plant studies partially supports this claim. Yearly catches of emerald shiners from the Cook Plant area (all samples taken from Lake Michigan) ranged from 0 to 49 fish during 1973 and 1979. In Pigeon Lake during 1978 and 1979 relatively high numbers of emerald shiners (466 and 128, respectively) were caught in Pigeon Lake. Scott and Crossman (1973) pointed out that in Lake Erie abundance of emerald shiners changed considerably from year to year so that a period of low abundance may be followed by one of great abundance.

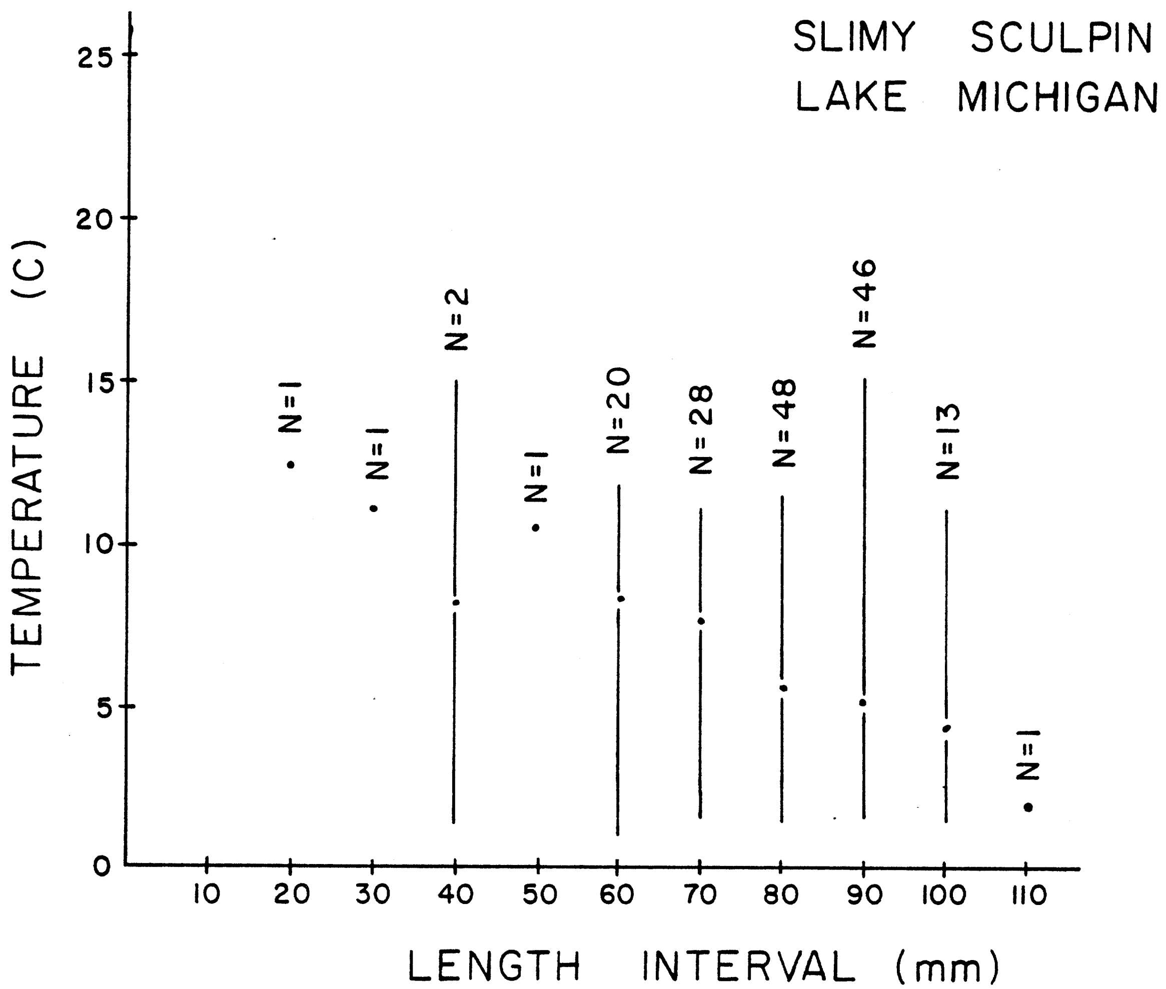


Fig. 63. Weighted-mean temperatures at which various sizes (10-mm length groups) of slimy sculpins were collected by all gear types from Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan, 1979. Vertical bars represent the range, N = number of fish.

In 1977 only four emerald shiners were captured; three in Pigeon Lake and one in Lake Michigan. However, in 1978, 50 individuals were caught in Lake Michigan and 466 were caught in Pigeon Lake. The majority of these 466 emerald shiners were YOY caught at beach station S (Lake Michigan influenced) at night.

Seven and 128 emerald shiners were caught in Lake Michigan and Pigeon Lake, respectively, during 1979. As in 1977 and 1978, all emerald shiners were caught in seines; during 1979 emerald shiners were caught at Lake Michigan beach stations Q (south discharge) and R (north discharge) and at Pigeon Lake station S (Lake Michigan influenced) and V (undisturbed Pigeon Lake), with the majority caught at station S.

In April 1979, 3 emerald shiners were caught in Lake Michigan and 21 were caught in Pigeon Lake; 3 of these 21 were caught at station V and 18 were caught at station S. Eleven emerald shiners were caught during the day and 13 at night during April. Most emerald shiners caught in April were apparently yearlings (25-64 mm, 40-mm modal length), the few others were adults (2- and 3-yr olds) and ranged from 65 to 104 mm. Fish were caught at water temperatures between 6.6 and 9.0 C.

Most emerald shiners were caught in May; 105 were caught in Pigeon Lake, all at station S (Lake Michigan influenced), and 2 were caught in Lake Michigan, at station Q (south discharge). Yearlings (15-54 mm, 40 mm modal length) made up the bulk of the May catch; only eight adults (65-104 mm) were caught. More emerald shiners in May were caught at night than during the day; there may be some active avoidance of the seine during the day. In May only four emerald shiners were determined to have slightly developed gonads (three females and one male); all the rest were immature except for a few with gonads which were not distinguishable.

After May, only a few emerald shiners were caught. One was caught at Pigeon Lake station S in July and in August three were caught, one each at stations S (Lake Michigan influenced), Q (south discharge) and R (north discharge). No YOY emerald shiners were caught in adult fish gear in 1979.

In 1978 emerald shiners congregated in the Pigeon Lake beach area in April, not in May as during 1979. The length ranges for yearlings were similar between years and the modal length for yearlings was slightly higher in 1978 (50 mm) than in 1979 (40 mm) (Appendix 6). As in 1979, highest emerald shiner catches were at Pigeon Lake station S. In April 1978 almost all of these emerald shiners were caught during the day. After April 1978, few emerald shiners were caught until October when 339 individuals (mostly YOY) were seined at station S; most were caught at night.

Emerald shiners appear in spring in the Pigeon Lake beach zone. During the summer, they apparently move to deeper water in Pigeon Lake or Lake Michigan. In the fall, they seem to congregate inshore in schools composed mainly of YOY. During the winter emerald shiners probably move to deeper water.

Larvae data indicated that spawning began as early as May and was still occurring in August (see RESULTS AND DISCUSSION - FISH LARVAE AND FISH EGGS, Cyprinidae Complex, Emerald Shiner and ENTRAINMENT STUDY). Largest catches of larvae were in entrainment samples, but some larvae were also collected in Pigeon Lake and Lake Michigan. Over 320,000 emerald shiner larvae were estimated to be entrained by the Campbell Plant during 1979 with most entrainment losses in August. In 1978 spawning was reported for June through late July. Note that emerald shiner larvae found in Lake Michigan may be the result of spawning activity in the discharge canal.

Emerald shiners were caught at temperatures ranging from 7.5 to 14.5 C in Lake Michigan and from 6.6 to 21.3 C in Pigeon Lake; most were caught at temperatures between 8.5 and 13.0 C in Pigeon Lake. There appeared to be no relationship between length of fish and temperature at capture. In 1978 younger fish tended to be caught at cooler temperatures and older fish were caught at warmer temperatures (Jude et al. 1979a).

Only 10 emerald shiners were collected in impingement samples during 1979 which yielded an estimate of 67 impinged for the entire year. These fish (80-110 mm) were probably all adults and were collected mostly in March, but also in February, April, May and September. In 1978 an estimated total of 72 emerald shiners was impinged; all of these fish were probably adults also. No emerald shiners were found in impingement samples during June-December 1977 (Zeitoun et al. 1978), but seven were found from February to September in 1974 (Consumers Power Company 1975).

All emerald shiners were collected in seines from 1977 to 1979, mainly in the spring and fall. Scott and Crossman (1973) report that emerald shiners spend the summer in offshore water and near the surface. Here they are not susceptible to trawls or bottom gill nets. However, Flittner (1974) noted that many emerald shiners were caught in bottom trawls in water less than 15 m.

Alewife catch in Pigeon Lake was relatively high in 1977 with 7094 individuals caught from June to December. In 1978 catch decreased substantially to 605 alewives for sampling from April to December. In 1979 alewife abundance in Pigeon Lake rebounded as 5178 individuals were caught from April to December. The numbers of emerald shiners caught correlate well with this sequence of alewife abundance. In 1978 it appears alewife abundance was low enough to allow the emerald shiners to produce a successful year class. In 1979 the alewives, which had high population levels in Pigeon Lake as in 1977, may have outcompeted emerald shiners so that a weak year class was produced. In 1978 many YOY emerald shiners were collected in October, but in 1979 no YOY were collected during the fall. Perhaps the congregation of YOY in the shallows of Pigeon Lake during the fall was missed by our sampling. It must also be remembered that considerable fluctuations in emerald shiner abundance are characteristic of their populations.

Brown Trout--

The number of brown trout caught in 1979 (88 from Lake Michigan and 1 from Pigeon Lake) decreased somewhat from 1978 (115 from Lake Michigan and 0 from Pigeon Lake). Brown trout were caught during all monthly sampling periods except December. As in 1978, April was the month of maximum catch (27 fish); few were caught after September (Appendix 6). The 1979 data suggest a nocturnal activity pattern; 82% were caught at night. Jude et al. (1979a) reported that brown trout feed mostly at night.

Beach seine hauls caught seven brown trout in Lake Michigan and one in Pigeon Lake; all were juvenile fish ($\leq$ 290 mm). All but two of the brown trout caught in 1979 were caught in 6 m of water or less; 65% were caught in 3 m of water or less. Juvenile brown trout were caught primarily in the beach zone during our 1978 and 1977 studies. In 1978, 78% of the total catch was caught in 3 m of water or less. Brown trout most likely favor the shallower depths for feeding at night and move out deeper during the day. In the vicinity of the Campbell Plant, brown trout fed heavily upon slimy sculpins in the spring and alewives throughout the rest of the year.

Although brown trout were caught over a wide range of water temperatures (3-21 C), 97% were caught between 7 and 15 C. The larger fish were caught in deeper cooler water than the younger smaller fish. Jude et al. (1979b) found a preferred water temperature of 4-14 C for brown trout in Lake Michigan off Bridgman, Michigan.

Gonad development data (Table 36) indicate a fall spawning period. Brown trout spawn in October and November in Lake Michigan (Becker 1976). Brown trout were impinged in very low numbers. Estimated impingement of brown trout for the entire year was 32 fish.

Brook Silverside--

Brook silverside was the eighth-most numerous species captured in Pigeon Lake during 1979 although it comprised only 0.46% of the total Pigeon Lake catch. Of 87 specimens collected in seines, 84 were caught at beach station V (undisturbed Pigeon Lake) and 3 were caught at beach station S (influenced by Lake Michigan). Number of brook silversides caught at station S has steadily declined since 1977 (Jude et al. 1978, 1979a) probably due to a steady increase in construction-related activities in the area over the same time period. Scott and Crossman (1973) noted that brook silverside may disappear from water that has become turbid. Curtailment of construction-related activity and corresponding diminution of turbid conditions in 1980 will likely result in brook silversides returning to station S.

Brook silversides first appeared in June (two 73-mm fish) in beach station V (undisturbed Pigeon Lake) seine hauls (Appendix 6). These fish had slightly developed and moderately developed gonads respectively and probably represented a remnant of the spawning population. Spawning for this species is assumed to occur around May (Jude et al. 1978, 1979a).

Table 36. Monthly gonad conditions of brown trout caught during 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. All fish examined in a month were included except poorly received specimens.

	Gonad condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Slight development	11	8	7			2	2		
	Mod. development				2		1	1		
Males	Well developed				1		1			
	Ripe-running									
	Spent									
	Slight development	14	7	2	3		1		1	
	Mod. development	1		2	1	1				
Females	Well developed	1				1	2	1		
	Ripe-running									
	Spent		1							
	Absorbing			1						
Immature				1	1	2	4	1	1	
Unable to distinguish					1		1			

Since brook silversides die soon after spawning, it is not surprising that adults were not sampled through summer. Newly hatched brook silversides initially occupy relatively deep water lacking vegetation; when YOY reach approximately 30 mm, they are large enough to actively avoid predation and move into shallower, seinable water (Scott and Crossman 1973). Four YOY brook silversides (25-44 mm) were caught in August at beach station V (undisturbed Pigeon Lake).

During September, 38 YOY silversides were seined, the most of any month. These fish ranged from 25 to 64 mm and all but two came from undisturbed beach station V. Two fish were captured at station S (influenced by Lake Michigan). Twenty and 23 brook silversides, respectively, were caught during October and November, final months of seine sampling.

During 1979 brook silversides were caught in water 9-19 C. The upper end of this temperature range reflects the relatively cool summer weather; it does not reflect the upper temperature tolerance of this species, since most brook silversides sampled during 1978 were caught at temperatures from 22 to 27 C (Jude et al. 1979a).

The small size and slender elongate body shape of brook silversides preclude the likelihood of impingement of this species since they would readily pass through the traveling screens. Also, rapid growth of young silverside ensures swimming competency at an early age. None were impinged while 2,632 larvae were entrained.

Chinook Salmon--

Chinook salmon were collected in field samples during every month except December. Sixty-seven chinook ranging from 77 to 940 mm were caught in Lake Michigan, while 12 salmon between 80 and 335 mm were caught in Pigeon Lake (Appendix 6).

Nearly 75% of the chinook sampled in 1979 were between 77 and 187 mm. Recently smolted salmon (77-114 mm) were caught during April and May; after feeding through the summer, these fish had grown to 149-187 mm by August and September. Two chinook (80-92 mm) were trawled in May, and gill nets were increasingly effective during later months. Most young salmon were caught in seine hauls. At Lake Michigan beach stations Q (south discharge) and R (north discharge), 14 and 19 chinook were seined respectively; fewer fish (5) were seined at station P (south reference). In Pigeon Lake, small chinook were caught during May (2), June (3) and July (6) at beach station S (influenced by Lake Michigan).

Chinook starting their second summer in Lake Michigan were between 200 and 328 mm in April and May. By November, these fish were around 420 mm. Bottom and surface gill nets in Lake Michigan caught 16 salmon (200-418 mm) at depths from 1.5 to 12 m during 1979. An immature 335-mm chinook was seined during October at Pigeon Lake beach station S (influenced by Lake Michigan). Three large chinook with well developed gonads were gillnetted in Lake Michigan during September. Two of these fish (935 and 940 mm) were males and one (850 mm) was female. Although it has not been documented, limited spawning by chinook salmon may occur in the Pigeon River (Jude et al. 1978).

Chinook were caught in Lake Michigan at temperatures between 7.2 and 15.9 C. There did not appear to be a relationship between temperature and size of fish. Water temperatures in Pigeon Lake when chinook were captured ranged from 12.6 to 21.3 C.

Impingement samples during 1979 included an estimated 143 chinook salmon between 100 and 400 mm. The greatest number of chinook impinged (60) occurred in April; none were impinged during January, February, June or September. Field sample catch of chinook salmon during 1979 (79) surpassed that of 1978 (33) and 1977 (3). Impingement totals for this species were identical in 1978 and 1979 (143), but no chinook were found in 1977 impingement samples (Zeitoun et al. 1978).

Mottled Sculpin--

Field collections during 1977 and 1978 indicated that mottled sculpins were uncommon in the area of the Campbell Plant as only four were caught during each of these years. They have increased during 1979 as 73 mottled sculpins were netted. Of these, 72 were seined in Pigeon Lake at Lake Michigan-influenced station S, while the remaining 1 was trawled in Lake Michigan at station E (12 m, south).

In Pigeon Lake, it is significant that 68 of the 72 mottled sculpins caught were seined at station S during September-November. This may reflect a seasonal movement of this species during autumn months to the shallow sandy, sparsely vegetated areas of Pigeon Lake. Although less pronounced, this trend was also apparent during 1977 and 1978 when all five mottled sculpins caught were seined at station S in October and November. Water temperatures at which the majority of mottled sculpins were captured during 1977-1979 ranged from 10.0-13.0 C. It is apparent that the sandy bottom, sparsely vegetated Lake Michigan-influenced area of Pigeon Lake is preferred over the densely vegetated habitat typified by station V (unaffected by Lake Michigan). From 1977 to 1979, no mottled sculpins were seined at station V.

A trend toward higher nocturnal catches of mottled sculpins was evident from 1979 data. We believe that mottled sculpins probably abandoned seinable depths of Pigeon Lake during daylight hours as a negative phototaxic response and retreated to deeper sections of the lake. This is substantiated by aquarium observations of this species as well as initial observations of the area near beach station S prior to daytime seining. No mottled sculpins could be observed in the area during daylight hours, nor were any mottled sculpins seen scurrying ahead of the seine during daytime sampling.

Sampling during 1979 substantiated the contention that mottled sculpins do occasionally enter Lake Michigan. One 80-mm specimen was trawled in December at station E (12 m, south). Construction of discharge/intake structures in Lake Michigan near the Campbell Plant may provide additional habitat for this species, which should result in a greater occurrence of mottled sculpins in Lake Michigan near the plant, similar to what occurred at the D. C. Cook Plant (Jude et al. 1979b).

Loss of mottled sculpins due to impingement at the Campbell Plant was minimal during 1979 with the majority impinged (26 of a total of 36) in March and April. During 1978 mottled sculpins were impinged only in April. It appears that maximum impingement of this species at Units 1 and 2 intakes occurs in early spring.

Largemouth Bass--

Largemouth bass first appeared in 1979 samples during June. Of five fish seined at Pigeon Lake beach station V (undisturbed Pigeon Lake), four were recently hatched YOY from 15 to 19 mm; the fifth bass measured 85 mm and was 1-yr old (Appendix 6). Bass in previous sampling years were found to spawn in late May-early June in Pigeon Lake so appearance of newly hatched

bass in June 1979 indicates consistency of spawning. There were no gonad condition data to confirm spawning time in 1979 since no adult bass were collected during the spawning season.

In succeeding months, YOY bass were still sampled only in low numbers. During July four fish (25-29 mm) were caught while in August nine bass (39-80 mm) were sampled. August was the first month of 1979 sampling during which bass were caught a beach station S (influenced by Lake Michigan); some were also caught at beach station V (undisturbed Pigeon Lake). This indicates dispersal behavior of bass that would be about 2-mo old in August.

September was the month of greatest bass catch (37) and was also the only month during which a few relatively mature bass were captured. Immature fish, comprising most of the sample (33 fish), ranged from 45 to 96 mm. Four bass that had at least partially developed gonads were between 96 and 247 mm. Catch at station S (influenced by Lake Michigan) was 3.5 times the catch at station V (undisturbed Pigeon Lake).

Four small fish in October (54-79 mm) and a single 74-mm individual seined in November were the last bass caught in 1979 field samples. Seining was not performed in December.

Impingement of largemouth bass was sporadic in 1979. A pattern of low numbers of impinged bass during spring and summer, increased impingement during the fall and a peak in December was observed in 1978 (Jude et al. 1979a). A similar pattern was not observed in 1979. Greatest estimated impingement in 1979 occurred in January (220) and October (716); impingement during other months never exceeded 95 fish (Appendix 9).

Similar sampling schemes for both field and impingement sampling were followed during 1978 and 1979. In Pigeon Lake 532 bass were seined in 1978 (Jude et al. 1979a) compared to only 60 in 1979. Similarly, impingement of largemouth bass decreased from an estimated 3061 in 1978 to 1202 in 1979. Since YOY bass strongly dominated all samples, the decrease in numbers between 1978 and 1979 implies that the 1979 year class was relatively unsuccessful. The spawning population of bass greater than 219 mm was determined to have decreased significantly between 1977 and 1978 due to angling mortality and competition from other large predacious fish present in Pigeon Lake If this trend persisted through 1979, the decreased number of spawners could result in decreased reproduction. From a different point of view, YOY bass may have faced competition in 1979 from an exceptionally large number of YOY yellow perch (see ADULT AND JUVENILE FISH, Yellow Perch).

Yellow perch are believed to hatch during mid-May in Pigeon Lake giving them 2-3 wk of growth before bass hatch in early June. Advanced growth and high density of yellow perch YOY may have combined to reduce chances for YOY bass to compete successfully for needed resources. Monthly densities of yellow perch at beach station S (influenced by Lake Michigan) were substantially less than densities at station V (undisturbed Pigeon Lake). Dispersal of YOY bass to station S in August and September may therefore have been induced by decreased competition in this area of the lake.

Largemouth bass were caught in water temperatures ranging from 9 to 22 C. Most fish, however, were found in water between 12.5 and 15.9 C.

Black Crappie--

Seining in Pigeon Lake resulted in the capture of 49 black crappies ranging from 52 to 163 mm (Appendix 6). All black crappies were collected at undisturbed Pigeon Lake beach station V at night. Presence of black crappies in the study area was limited in 1979; single specimens were seined in June, July, August and November. September sampling accounted for the greatest number of black crappies (45), most of which were YOY.

Black crappies were sampled at temperatures from 8 to 22 C. In September, when most black crappies were caught, water temperature at station V (undisturbed Pigeon Lake) was 15.9 C.

Impingement of black crappies in 1979 was estimated at 432. Estimated impingement in 1978 (406) was comparable to 1979, though numbers impinged during any given month did not correspond closely between the 2 yr.

Field catches of black crappies were greater in 1977 (183) and 1978 (246) than in 1979 (49). Neither adults nor YOY were caught during 1979 in numbers comparable to other years. As with other species (see ADULT AND JUVENILE FISH, Largemouth Bass, Golden Shiner, etc.), it may be that the pervasive presence of adult and YOY yellow perch limited the ability of black crappie to spawn or survive near station V (undisturbed Pigeon Lake).

Two crappies with moderately developed gonads were impinged, one each in January and February. Most of the other black crappies, whether in field or impingement samples, were immature; a few had slightly developed gonads.

Round Whitefish--

Occurrence of round whitefish in our sampling program has changed markedly during the past year. In 1977 and 1978, 8 and 10 round whitefish, respectively, were collected; 44 round whitefish were captured in 1979. This species was caught only in gill net and trawl operations in Lake Michigan at depths of 1.5 to 15 m in water ranging widely in temperature (3.9 to 14.5 C). Most round whitefish caught were adults. In 1979 these fish ranged from 163 to 473 mm; whereas, in 1977 and 1978 lengths ranged from 141 to 482 mm and 230 to 470 mm, respectively.

In the 1979 catch 12 of the round whitefish were males and 24 were females. Males averaged 363 mm and 493 g while females were 345 mm and 416 g. Although most fish were mature, none showed gonads to be in ripe, spent or absorbed condition. Nineteen of these fish were collected in October. Round whitefish spawn in November over a gravel substrate at 3 to 16 m in Lake Michigan (Scott and Crossman 1973). The increased appearance of these fish in the study area in October (Appendix 6) at 6 and 9 m may be related to initiation of spawning activities.

The general increase in abundance of round whitefish in our study area for 1979 did not appear to be influenced by construction of offshore intake and discharge structures. In October six fish were collected at reference station C (6 m, south) and five fish were taken at station L (6 m, south discharge). Throughout the year, round whitefish were captured predominately between 6 and 12 m.

The round whitefish has a subterminal mouth and feeds on benthic invertebrates. Early in the year, round whitefish may have been actively feeding on chironomids. Analysis of the stomach contents of round whitefish caught in April revealed them to be full of chironomids. Winnell and Jude (1979) reported maximum densities of chironomids to occur at 6, 9 and 12 m during April-October sampling. During the fall and winter months, however, round whitefish may have become more abundant at 6 to 12 m due to congregation prior to spawning, or they may have moved into the area to feed upon lake trout eggs. In November particularly, lake trout caught in gill nets were found to be in ripe and running condition. Round whitefish captured in November were found to have eaten eggs, and judging from the size, coloration and season, these were lake trout eggs. As many as 20 to 30 eggs were found in each stomach. The round whitefish has not been an important species in the area in the past. Its increased abundance in the area may be a response to the newly created riprap, both as a source of spawning substrate and food, provided at least in part by eggs laid by spawning lake trout.

Examination of round whitefish caught in our study revealed the presence of a parasitic copepod on the gill filaments. The parasite is believed to be Salmincola edwardsii (Hoffman 1967). The effect of this parasite on the health of the fish remains unknown, however as many as 35 have been found on the gill filaments of a single fish.

Gizzard Shad--

Gizzard shad were represented in field samples during each sampling month in 1979 though they were not common overall. Of 37 specimens collected, 35 were captured in Lake Michigan and 2 were caught in Pigeon Lake (Appendix 6). Similar numbers of gizzard shad were sampled in bottom gill nets, trawls and seines; surface gill nets did not catch any gizzard shad in 1979.

In April through September, all (10) gizzard shad were captured in water 3 m deep or less. Much of the population may have been concentrated in or near the Grand River where substantial gizzard shad spawning is believed to occur from late spring through summer (Jude et al. 1978). Relatively large individuals (395-467 mm) were found in samples through August; two smaller fish (88 and 135 mm) caught in September were probably YOY. October, November and December samples included a mixture of YOY and adult gizzard shad.

During October, gizzard shad were collected at a wide range of depths (1.5-12 m) in Lake Michigan and were more numerous than during any other month (21 specimens). Depth of capture and size of fish did not appear to be related. Also in October, the first of two gizzard shad was seined at Pigeon

Lake beach station S (influenced by Lake Michigan). Few gizzard shad have been sampled in Pigeon Lake through 3 yr of sampling (Jude et al. 1978, 1979a).

Small numbers of gizzard shad were collected in November and December. Two shad were caught in Lake Michigan and one was seined in Pigeon Lake during November. Trawling in December captured two gizzard shad from Lake Michigan.

Temperature range at time of capture varied somewhat for each sampling gear, but overall gizzard shad were caught in water from 5 to 15 C. Seventy percent of these fish occurred in water between 11 and 13 C.

Estimated impingement of gizzard shad during 1979 totalled 40,573. More than half of these (20,872) were impinged during January; variable numbers of fish were impinged during other months, but most occurred during winter (Appendix 9). Gizzard shad probably occupy deep water in Lake Michigan during winter (Bodola 1964; Jude et al. 1979a) and few shad ever enter Pigeon Lake where the Campbell Plant's intake canal is located. Impinged gizzard shad are therefore thought to originate from the substantial population known to inhabit the discharge canal (Jude et al. 1979a). The intake forebay of the plant is prevented from freezing during cold weather by recirculation of heated water from the discharge canal to the intake canal. The recirculation operation allows fish inhabiting the discharge canal to move to the intake canal where they are consequently subject to impingement.

Gizzard shad YOY began appearing in impingement samples in August, 1 mo before YOY were collected in field samples (Appendix 8). Months of high impingement did not correspond with months of large field catches.

Total estimated impingement of gizzard shad was markedly decreased in 1979 (40,573) compared to 1978 (74,727) and 1977 (165,219). The relatively huge total estimated in 1977 included numbers from only 7 mo of the year. Number of gizzard shad entering the discharge canal from Lake Michigan was probably reduced in fall 1979 due to construction of the dam between the canal and Lake Michigan and the placement of offshore intake and discharge pipes.

Gizzard shad could not be readily categorized according to gonad development (Table 37). Fish with slightly and moderately developed gonads occurred throughout the year. Two males with well developed gonads were caught; one in February and one in October.

Rock Bass--

Thirty-seven rock bass ranging from 30 to 165 mm were caught in 1979; all came from Pigeon Lake. Most rock bass collected (35 of 37) were seined at beach station V (undisturbed Pigeon Lake); only two were taken at beach station S (influenced by Lake Michigan). No rock bass were caught at station M (influenced by Lake Michigan) where gillnetting was performed only during April.

Table 37. Monthly gonad conditions of gizzard shad collected in impingement samples during 1979 at the J. H. Campbell Plant, eastern Lake Michigan. All fish examined in a month were included except poorly received specimens.

	Gonad condition	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Slight development	154	94	45	26				1		16	2	15
	Mod. development	17	26	8	5								2
Males	Well developed		1										
	Ripe-running												
	Spent												
	Slight development	108	81	34	11				1		9	2	13
	Mod. development	15	5	3	2								
Females	Well developed												
	Ripe-running												
	Spent												
	Absorbing												
Immature		123	66	39	9	1	1		36	23	81	221	113
Unable to distinguish		81	77	7	9				2	1	4	16	23

Of the 37 rock bass collected in 1979, 14 were from 30 to 52 mm, 7 from 77 to 103 mm and 16 from 109 to 165 mm. Based on length-age data reported by Carlander (1977) and Harlan and Speaker (1969), these three size groups were respectively YOY, yearlings and 2- and 3-year-olds. In 1979 comparable numbers of rock bass were caught in July (7), August (8) and October (9). Slightly higher catches (13) were made in September. No rock bass were caught during April-June 1979 and only a few were found during the same period in 1978. Peak catches of rock bass occurred during July in 1977 and June in 1978.

Rock bass mature at 2 yr of age and spawn at 3 yr (Hile 1941). Most adult rock bass collected during July-September 1979 had only slight gonad development, suggesting that spawning had taken place before July. A few rock bass larvae 11-12 mm were collected in a supplementary sampling at beach station T (influenced by Pigeon River) during June 1978, suggesting that spawning took place during May or June. These data agreed with Carlander (1977) who reported rock bass spawn during May and June in Indiana and Illinois.

Rock bass populations appeared to be declining during the period 1977-1979. At beach station V (undisturbed Pigeon Lake), 86 rock bass were caught in 1977, 73 in 1978 and 35 in 1979. Catches at beach station S (influenced by Lake Michigan) remained about the same during the 3-yr period. Decline of catches at station V may be related to heavy boat traffic in the

western portion of Pigeon Lake. During 1977 and 1978 most rock bass were caught in seines. Deletion of gillnetting during summer and fall, 1979, therefore, did not affect rock bass catches. More rock bass were caught at night than during the day. Rock bass were caught in water temperatures of 11-23 C.

One rock bass was removed from the traveling screens in May, one in June and another in August. Two other rock bass were found in November impingement samples. Of these five impinged rock bass, four were adults 140-181 mm and one was a 46-mm immature individual. Twenty-eight rock bass were estimated impinged in 1979. This number was comparable to the projected rock bass loss of 21 in 1978. A larger number of rock bass (122) were impinged during June-December 1977 (Zeitoun et al. 1978).

Rainbow Trout--

In 1979, 29 rainbow trout were caught in the study area. This is the largest annual catch for the years 1977-1979; 10 and 15 were caught in 1977 and 1978 (Jude et al. 1978, 1979a). All rainbows in 1979 were caught in Lake Michigan. Deletion of a gill net station in Pigeon Lake was the most probable cause for no rainbow trout being caught in Pigeon Lake.

Nearly 59% of the rainbow trout were caught during April in 6 m or less water. All were large adult fish (540-740 mm). One was caught in a beach seine and another in a bottom trawl; 8 in surface gill nets and 7 in bottom gill nets.

Populations of both spring- and fall-spawning rainbow trout were planted in Lake Michigan (Daly et al. 1975) and our gonad development data (Table 38) indicated that the former were found predominately in the vicinity of the Campbell Plant.

Supplementary sampling and visual observations disclosed that adult rainbow trout were utilizing the discharge canal during late winter and spring 1980. These fish were feeding very heavily upon gizzard shad and alewives which were in the channel. Seasonal high densities of forage fishes near thermal discharges into Lake Michigan (Romberg et al. 1974) could attract salmonid fishes and may provide energetic advantages to plume residents.

Lake Whitefish--

Although a common inhabitant of the inshore water of the Great Lakes, the lake whitefish is not frequently encountered in our nets. During 1977 11 fish were taken at night by trawl and bottom gill net at depths greater than 6 m. These fish ranged from 261 to 466 mm. In 1978 nine whitefish were recovered from similar gear as well as surface gill nets. All but one were taken at night again at depths greater than 6 m. Lake whitefish in 1978 ranged from 200 to 690 mm.

Table 38. Monthly gonad conditions of rainbow trout caught during 1979 in Lake Michigan near the J. H. Campbell Plant, eastern Lake Michigan. All fish examined in a month were included except poorly received specimens.

	Gonad condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Males	Slight development									
	Mod. development	1							2	
	Well developed								1	
	Ripe-running	1								
	Spent									
Females	Slight development	1								
	Mod. development	2						3	1	
	Well developed	11	1							
	Ripe-running	1								
	Spent									
	Absorbing									
Immature								1	1	
Unable to distinguish								1	1	

The catch of lake whitefish increased threefold from 1978 to 1979. During 1979, 26 lake whitefish were recovered, all were caught at night in trawls or bottom gill nets. Although all sizes were caught in both gear, more fish were taken by gill net than trawl which seems likely due to sampling duration. All but one were captured at the south transect and all but three at depths greater than 6 m. These lake whitefish ranged from 155 to 597 mm. Ten fish were males averaging 436 mm and 1065 g and 11 were females averaging 516 mm and 1740 g. Examination of gonad condition revealed that most adults exhibited only slight to moderate development of the gonads. All whitefish were captured between June and September, prior to spawning which takes place in November or December in water less than 8 m (Scott and Crossman 1973).

Lake whitefish feed on benthic invertebrates. Examination of the stomach of one fish taken in June revealed chironomids to be an important forage item. According to Ferguson (1958), whitefish prefer water temperatures near 11 C. During all 3 yr of the study, whitefish were commonly taken near or below this temperature. They were found at 4.5 to 10.8, 6.0 to 8.2 and 3.3 to 14.2 C in 1977, 1978 and 1979, respectively. Most whitefish in 1979 were captured at 9.5 to 11.5 C.

Pumpkinseed--

During 1979, 23 pumpkinseeds were collected in Pigeon Lake. None were collected in Lake Michigan. One pumpkinseed, a 75-mm male, was collected at beach station S (influenced by Lake Michigan) in September. All other pumpkinseeds were collected at beach station V (undisturbed Pigeon Lake).

No pumpkinseeds were caught in April, May, October or November. No YOY were collected during the entire sampling season. At beach station V (undisturbed Pigeon Lake), 4 pumpkinseeds were caught in June, 6 in July, 3 in August and 10 in September.

Numbers of pumpkinseeds caught in 1979 (23) were much lower than in 1978 when 114 fish were collected (Jude et al. 1979a). In contrast, numbers of bluegills, a very closely related, competing species, increased in 1979 (see ADULT AND JUVENILE FISH, Bluegill, for more details). Different possible explanations may exist for these findings. Bluegills may be outcompeting pumpkinseeds in the Pigeon Lake environment. Or, we did not sample prime pumpkinseed spawning and nursery habitats. Areas covered by our seine hauls in no way sample all suitable pumpkinseed habitat. Large bluegill catches indicate that bluegills were occupying these areas and using them heavily as nurseries. Quite possibly, pumpkinseed nursery areas existed outside our sampling area.

Pumpkinseeds are a warm-water species and all but the one fish taken at beach station S (influenced by Lake Michigan - temperature 12.5 C) were collected at water temperatures 15.9 C and higher.

Eight pumpkinseeds were collected in impingement samples at the Campbell Plant in 1979. Expanding this number to a total number impinged over the entire year results in 46 pumpkinseeds lost to impingement. This relatively small number of fish lost would have little or no effect on Pigeon Lake pumpkinseed populations.

Coho Salmon--

The number of coho salmon caught during 1979 decreased somewhat from 1978 levels. During 1979, 18 were caught in Lake Michigan and 3 in Pigeon Lake compared to 56 and 18 for 1978. Only a few juvenile ($\leq$ 165 mm) fish were caught in 1979, which is contrary to 1978 findings. During June and July 1977 and 1978, moderate numbers of small coho were caught in the beach zone. Numbers of coho salmon planted by the MDNR in the spring of 1979 for the Grand, Muskegon, St. Joseph and Black Rivers were increased over 1978 plants. Even though more coho salmon were planted near the study area in 1979, a decrease in our catch of juvenile coho salmon was observed.

Adult coho salmon were caught in April, September and October suggesting a shoreward movement in spring and fall. September and October were months of peak catch of adult coho salmon during 1977 and 1978.

Coho were tagged as part of a multi-state tagging program initiated in the spring of 1978 (see Jude et al. 1978, Coho Salmon). We caught six of these coho salmon. Three were planted in the Grand/Muskegon Rivers, two came from the Little Manistee and one from the St. Joseph River. In 1979, 26 were estimated impinged. They ranged from 125 to 404 mm.

Golden Shiner--

Sixteen golden shiners were seined at Pigeon Lake beach station S (influenced by Lake Michigan) in May (Appendix 6). These fish ranged from 34 to 64 mm and were all immature. Water temperature was 12.6 C.

Two fish measuring 129 and 145 mm were collected in July; the smaller individual was a male with slight gonadal development. The larger fish was in too poor condition to evaluate gonad condition. Captures in July occurred at station V (undisturbed Pigeon Lake) in water 22.0 C.

August was the only other month that golden shiners appeared in 1979 field samples. Two fish were seined at station V (undisturbed Pigeon Lake), an immature (52 mm) and a female (125 mm) which had slightly developed ovaries. Water temperature during August collections was 17.5 C.

Estimated total number of golden shiners impinged in 1979 was 199. Impingement of golden shiners only occurred during 4 mo: January (21), March (52), April (120) and December (6) (Appendix 9). Gonads of fish impinged in March and April were slightly or moderately developed; golden shiners in January and December were immature. All fish were between 75 and 134 mm (Appendix 8).

Number of golden shiners in Pigeon Lake field samples was spectacularly low in 1979 compared with other sampling years (see Jude et al. 1978, 1979a). Similar numbers were caught in 1977 (2615) and 1978 (2220) in spite of quite different sampling schemes during the 2 yr. In 1979 only 20 golden shiners were caught. Impingement of golden shiners on the other hand was relatively high in 1979 (199) compared with 1977 (0) and 1978 (21).

Composition of field catches during the 3 sampling yr differed considerably. In 1977, sampling began in June. Golden shiners in Pigeon Lake spawn during May and beach station T (influenced by the Pigeon River) was determined to be the preferred spawning habitat for this species (Jude et al. 1978, 1979a). It is therefore not surprising that most of the golden shiner catch in 1977 was comprised of YOY and that over 90% were captured at station T.

Earlier sampling dates (April and May) in 1978 resulted in the capture of numerous golden shiner adults which were congregating near beach station V (undisturbed Pigeon Lake) for spawning purposes (Jude et al. 1979a). Station T (influenced by Pigeon River) was not sampled in 1978 and only a few YOY golden shiner occurred in seine samples at stations S (influenced by Lake Michigan) and V.

Neither YOY nor adult spawning golden shiners were caught in large numbers in 1979. A possible explanation for the decline in catch is related to extensive spawning at station V (undisturbed Pigeon Lake) by yellow perch (see ADULT AND JUVENILE FISH, Yellow Perch). Adult golden shiners congregating near station V in April or May could have been displaced by adult yellow perch. This would explain why adult golden shiners were not captured at station V in 1979 as they were in 1978. Displaced golden may have dispersed in an attempt to find alternate spawning grounds and the fish which dispersed to the intake canal (where golden shiner do not normally occur) were more susceptible than normal to impingement. Supporting this contention is the unusually large number of golden shiners (with moderately developed gonads) which were impinged during April. Further evidence of dispersal was the capture in May of 16 golden shiners at station S (influenced by Lake Michigan). However, even if golden shiners were not totally displaced from station V (undisturbed Pigeon Lake), but did successfully spawn there, it is likely that abundant YOY yellow perch would have preyed on and competed with YOY golden shiners for food. Thus, absence of YOY golden shiners from our samples would be expected. Since station T (influenced by Pigeon River) was not sampled in 1979, it is not known whether yellow perch spawning was also extensive in that area of Pigeon Lake. Since station T is preferred spawning habitat for golden shiner, competition from yellow perch at this station would potentially have a greater effect on the entire Pigeon Lake golden shiner population than would competition believed to have occurred at station V (undisturbed Pigeon Lake).

Tadpole Madtom--

Tadpole madtom populations appeared to have remained stable in Pigeon Lake during 1977-1979. Seining at beach station S (influenced by Lake Michigan) and beach station V (undisturbed Pigeon Lake) produced 18 tadpole madtoms in 1977 and 17 in 1978. Seventeen tadpole madtoms were caught at these stations in 1979.

As was found in 1978, more tadpole madtoms were collected at beach station V (15) than at station S (2) in 1979. The 1979 catch of madtoms contained eight adults (66-83 mm) and nine immature individuals (30-52 mm). Tadpole madtoms were reported to spawn in May in Wisconsin (Becker 1976) and in June or July in Canada (Scott and Crossman 1973). In 1979 a spent female (80 mm) was collected in June suggesting that in Pigeon Lake, tadpole madtoms also spawn during May or June. The six other adults collected in August, September and October showed slight gonad development. Of the nine immature madtoms, two (30, 34 mm) were taken in August and seven (42-52 mm) were caught in September and October. Based on our data collected during 1977 and 1978, these immature madtoms were all YOY. Tadpole madtoms were collected in water temperatures of 11-19 C.

The projected number of tadpole madtoms impinged during 1979 was 42. Yearlings (53-62 mm) were impinged in August and September. Adult madtoms (65-85 mm) were found in impingement samples during June, July, August and November (Appendix 8).

Sand Shiner--

The sand shiner prefers sandy, sparsely vegetated shallows of lakes and large rivers. In the Lake Michigan area it is found in tributary streams close to Lake Michigan and occasionally along the shore of Lake Michigan (Becker 1976). In this study, sand shiners were only collected in Pigeon Lake and only during 1978 and 1979. In 1979 three immatures (30-42 mm) were caught in April at station S (Lake Michigan influenced) in a seine. Two were caught during the day and one at night when water temperatures were respectively 8.5 and 6.6 C. In May two immatures (38 and 40 mm), two adult males (58 and 68 mm) and one adult female (65 mm) were seined at station S (Lake Michigan influenced) during the day at a temperature of 13.0 C. Thirteen adults were seined at station V (undisturbed Pigeon Lake) in June during the day; two of these adults were females with well developed ovaries. These gonad data suggest spawning may have occurred in Pigeon Lake in June or early July. Sand shiners may be attracted to warmer water for spawning. In June all individuals were caught at station V where temperature at sampling time (19.5 C) was considerably higher than at station S (17.0 C). In 1978 two immature sand shiners were seined at station S (influenced by Lake Michigan), one in September and October. It appears some sand shiners move into the beach zone of Pigeon Lake in spring; spawning occurs there in June or July, and they then move to deeper water in Pigeon Lake or into Lake Michigan during the summer. Some sand shiners return to the Pigeon Lake beach zone during fall.

Fathead Minnow--

Fathead minnows were scarce in the study area. Catches of this species, however, did increase during 1977-1979. No fathead minnows were caught in 1977; 3 were caught in 1978 and 15 (all from Pigeon Lake) in 1979.

Of the 15 fathead minnows collected in 1979, one was a 30-mm individual seined at station S (influenced by Lake Michigan) during May. Based on length-age data reported by Carlander (1969), this fish was a yearling. The remaining 14 fathead minnows were adults (39-65 mm), of which 4 were seined at station V (undisturbed Pigeon Lake) in June and July and 10 were seined at station S during May, June, July, September and November. These data suggested that fathead minnows preferred the areas influenced by Lake Michigan.

Most adult fathead minnows collected in 1979 showed slight or moderate gonad development. Well developed gonads were observed in a 53-mm female collected at station S during July suggesting that spawning took place during this month. These data agreed with Scott and Crossman (1976) who reported fathead minnows spawn from May through August. Fathead minnows were caught in water temperatures from 9 to 25 C.

Five fathead minnows were collected in impingement samples, three in April and one in January and March. The total number impinged was estimated at 29. Impinged fathead minnows (56-77 mm) were all adults showing slight gonad development. This species was not found in impingement samples

collected during January-December 1978 (Jude et al. 1979a), June-December 1977 (Zeitoun et al. 1978) or January 1974-March 1975 (Consumers Power Company 1975).

Carp--

The carp is native to temperate sections of Asia, but has been widely introduced into the United States and Canada (Scott and Crossman 1973). Carp prefer an environment with a shallow, marshy area and dense aquatic vegetation in which to feed and spawn as well as a deepwater area for overwintering. The study area, which includes the inshore area of Lake Michigan in the Campbell Plant vicinity, Pigeon Lake and the intake canal, offers this combination.

Each year from 1977 to 1979 a few carp have been caught. In 1977, 15 carp were collected from Pigeon Lake and 7 from Lake Michigan. In 1978, 8 carp were caught in Pigeon Lake and 13 in Lake Michigan. Note that in 1977 five carp in Pigeon Lake were caught at stations T (beach-Pigeon River influenced) and Y (open water-Pigeon River influenced); these stations were not sampled after 1977. Station M (Lake Michigan influenced), where the majority of carp were caught in 1977 and where one was captured in 1978, was dropped from the sampling schedule in 1979.

Ten carp were caught in 1979; all were adults and all were caught in Lake Michigan. Three of these carp were caught in trawls; two at night in August at stations F (15 m, south) and N (9 m, north) and one at night in November at station C (6 m, south). The other seven were caught in bottom gill nets from April through November at stations A (1.5 m, south), B (south, 3 m), L (6 m, north) and U (6 m, north discharge). Of these seven carp, only two were caught during the day. Six were males and four were females; gonad conditions ranged from slightly to fully developed. Lengths of these fish ranged from 575 to 744 mm which were similar to length ranges of carp caught in Lake Michigan in 1977 and 1978. Carp were caught at temperatures from 3.9 to 16 C with most being caught between 8 and 10 C.

Many carp larvae were collected in 1979 particularly in entrainment samples (see RESULTS AND DISCUSSION - FISH LARVAE AND FISH EGGS, Carp). Over 11 million carp larvae were estimated entrained during 1979. Larvae data indicate that carp spawning began in mid-May probably in the intake canal. Carp have been sighted on occasion in the intake canal from 1977 to 1979. Spawning appeared to have concluded in August.

No adult carp were collected in Pigeon Lake in 1979 although they were observed in the intake canal and were seen during electroshocking activities. A few immatures have been seined in Pigeon Lake in 1977 and 1978 and some were found in impingement samples from 1977 to 1979 which indicates that Pigeon Lake is suitable for carp growth.

One immature carp (90 mm) was collected in an impingement sample in November during 1979 to yield an estimate of five carp impinged by the Campbell Plant during 1979. Four carp were found in impingement samples in 1978 and four were found in 1977.

During 1977 and 1978, but not in 1979, proportionately high numbers of carp were caught at beach stations influenced by the onshore thermal discharge. In general, carp are attracted to thermal discharges (Jude et al. 1979a). We expect carp will be attracted to the offshore thermal discharge when Unit 3 becomes operational.

Golden Redhorse--

A species which is caught sporadically, the golden redhorse has increased in occurrence in our samples. In 1977 only one 465-mm male was collected in Pigeon Lake. Two males and three females (425 to 636 mm) were recovered from 1978 samples. One of these fish was taken in Pigeon Lake and four were observed in Lake Michigan samples collected at the 1.5- and 6-m contours. Ten golden redhorses were recovered in 1979 samples, four males and six females. These fish ranged in length from 400 to 595 mm and were captured at 1.5 to 6 m.

Throughout the 3-yr study period, golden redhorses have been captured in bottom gill net sets (one was captured in seine hauls) usually at 9.7 to 20.0 C. In 1977 the single individual was taken in October, but in 1978 and 1979, golden redhorses occurred in June, July and September samples. All individuals collected have been adults. In the July 1979 samples five fish were examined and gonad condition showed they had recently spawned. As stated by Jude et al. (1979a) these fish may move downstream and out into Lake Michigan after spawning in the upper reaches of the Pigeon River. Little is known about the biology of this species in the Great Lakes; Scott and Crossman (1973) and Pflieger (1975) felt this species spawned during April and May.

Brown Bullhead--

Nine brown bullheads were caught in 1979, all from station V (undisturbed Pigeon Lake). The three largest brown bullheads in the 1979 samples included a 316-mm female with well developed gonads, a 280-mm adult with undetermined sex and a 269-mm male with a slight gonad development. These adults were collected during June, July and October respectively. The remaining six brown bullheads were immature individuals 27-46 mm caught in August and September. Since brown bullheads spawn during May and June (Scott and Crossman 1973), these small brown bullheads were probably YOY. All brown bullheads collected in 1979 were caught at night. Field sampling during 1977 indicated that brown bullheads were the most common bullhead species in Pigeon Lake, but the majority inhabited the eastern portion of Pigeon Lake which was not sampled in 1978 and 1979. Brown bullheads were scarce at 6-m station M (influenced by Lake Michigan) and beach station S (influenced by Lake Michigan) during 1977-1979; most were caught at water temperatures of 11-23 C.

Twenty-nine brown bullheads were estimated impinged by the plant during 1979 (see IMPINGEMENT). Larger impinged brown bullheads (164-305 mm), probably all adults, were collected during October and November. A 44-mm YOY was impinged during March and a 54-mm yearling, during December.

Substantially larger numbers of brown bullheads (220) were impinged during 1978. Reasons for the decline of brown bullhead impingement in 1979 are not known.

Banded Killifish--

Numbers of banded killifish collected have varied considerably during study years 1977-1979. Only two banded killifish were captured in 1977; both were seined at station V (undisturbed Pigeon Lake) in November (Jude et al. 1979a). However in 1978, 51 individuals (25-54 mm) were seined in Pigeon Lake; 3 at station S (Lake Michigan influenced) and 48 at station V (undisturbed Pigeon Lake). Also in 1978 one banded killifish (65 mm) was caught in a night plankton tow at beach station V.

In 1979 nine banded killifish (36-52 mm) were captured, all were seined in Pigeon Lake. Three of these fish were seined at station V during the day in June; one was a female (52 mm, 1.2 g) with slightly developed ovaries. Two individuals were caught at night in August at station V; one each was caught at stations S and V in September at night, and two were collected during the day at station S in October (Appendix 6). Banded killifish prefer warmer temperatures; all were caught at water temperatures between 12 and 20 C. Lengths at which these killifish were caught corresponded to age-groups 0 and 1 fish according to Scott and Crossman (1973); almost all killifish caught in 1977 and 1978 were in these age-groups.

During the 3 yr of the study (1977-1979), the higher catch at station V compared to station S indicates a preference for the denser aquatic vegetation and more extensive area of shallow water of beach station V. Banded killifish feed in schools and in 1978 a school was seined in August at night, when 36 individuals were caught (36 of the 51 caught for the year). Slight shifts in these schools may have reduced the killifish catch from levels observed in 1977 and 1979.

Northern Pike--

Only eight northern pike were caught in 1979 standard sampling. Greater numbers of pike were caught in previous sampling years due largely to yearly changes in the Pigeon Lake sampling scheme. Number of Pigeon Lake gill net stations decreased from two in 1977 to one in 1978 to zero in 1979. Similarly, the number of Pigeon Lake seining stations went from three in 1977 to two in 1978 and 1979. Absence of a Pigeon Lake gill net station in 1979 (see Methods) especially affected northern pike catch; past years' data have indicated that gill nets were appreciably more efficient than seines at catching northern pike.

Pike seined from Pigeon Lake in 1979 were between 81 and 560 mm (Appendix 6). Six of the eight fish were caught at beach station V (undisturbed Pigeon Lake) and two pike were caught at beach station S (influenced by Lake Michigan). Catches of northern pike were somewhat

sporadic occurring in May (1), June (3), September (3) and October (1). Temperature extremes at which northern pike were captured were 18.0 C (June) and 11.5 C (October).

Compared with previous years, relatively large numbers of northern pike were impinged in 1979. Months of highest estimated impingement were March (93), April (45), July (31) and December (108) (Appendix 9). Total northern pike impingement was estimated at 285. Age-growth data indicate that all impinged pike were YOY or 1-yr old (Appendix 8). The 1-yr-old segment of the northern pike population was found to have increased significantly in Pigeon Lake between 1977 and 1978 and this increase in numbers would increase the potential for impingement of young pike.

Gonad condition of most northern pike sampled (whether seined or impinged) was immature or slightly developed. A notable exception was a female with well developed gonads which was impinged in March. Also a supplementary gill net set at station M (influenced by Lake Michigan) in April caught three male northern pike with moderately developed gonads and a female with spent sex products. These are scant data from which to draw conclusions, but the implication that northern pike spawning occurred sometime around April 1979 is consistent with previous year's findings in Pigeon Lake (Jude et al. 1978, 1979a) and with northern pike spawning time in Michigan reported by Carbine (1942).

Growth, condition and density (kg/ha) of northern pike in Pigeon Lake were all found to be average or above average compared to pike data from other lakes found in the literature. Population size of adult northern pike (greater than 299 mm) in Pigeon Lake was found to be stable between 1977 and 1978. Stomach analysis showed that northern pike exploit forage species which are present in Pigeon Lake largely because of the constant connection between Lake Michigan and Pigeon Lake. These forage species include gizzard shad, alewife, yellow perch and spottail shiner.

Beyond plant operations, the greatest threat to the northern pike population in Pigeon Lake appears to be illegal gillnetting. Commercial gill nets 244 m in length were occasionally set in Pigeon Lake during 1979, taking an unknown, but possibly significant toll on the northern pike population (R. Bleich, personal communication, Conservation Office's Michigan Dept. of Natural Resources, Grand Haven, Mich.).

Channel Catfish--

Lake Michigan samples taken at the south reference transect in 1979 included seven channel catfish ranging from 55 to 590 mm (Appendix 6). Consistent with previous years' sampling, channel catfish did not occur in the sampling area in 1979 until August when a 523-mm female was gillnetted in 3-m water. Catfish may migrate to Lake Michigan from rivers (such as the Grand and Pigeon Rivers).

Three channel catfish (485-590 mm) in September and two (375 and 590 mm) in October were also gillnetted. Depth of capture varied from 1.5 to 9 m. Of the fish caught in September, one male had moderately developed gonads and one female was absorbing eggs. Channel catfish normally spawn in late spring-early summer at temperatures between 23.9 and 29.5 C (Scott and Crossman 1973).

In December, a single channel catfish was trawled from a depth of 9 m. This was a 55-mm immature fish caught at 4.0 C. Catfish captured in gill nets were caught in water from 12.4 to 15.3 C.

An estimated 53 channel catfish were impinged during 1979 (Appendix 9). Most fish were small (55-94 mm) though two fish greater than 400 mm were also impinged (Appendix 8). Channel catfish are known to inhabit the discharge canal and a proportion of the impinged fish may originate from this population. In 1978, 100 channel catfish were impinged (Jude et al. 1979a).

Smallmouth Bass--

Smallmouth bass were first recorded in the vicinity of the Campbell Plant during January 1974 to March 1975 when 156 were collected in weekly impingement samples (Consumers Power Company 1975). During the 3-yr preoperational study, smallmouth bass occurred infrequently. In 1977 five smallmouth bass were collected from Pigeon Lake, two at station T (influenced by Pigeon River), one at station V (undisturbed Pigeon Lake) and two at station M (influenced by Lake Michigan) (Jude et al. 1978). According to Zeitoun et al. (1978), no smallmouth bass were impinged during 1977.

Sampling in 1978 accounted for 14 smallmouth bass from Pigeon Lake and 2 from the beach zone of Lake Michigan (Jude et al. 1979a). Those fish collected in Pigeon Lake occurred at beach station S (influenced by Lake Michigan) and V (undisturbed Pigeon Lake); however, sampling at Pigeon River stations T and Y had been deleted in 1978. During 1978, 41 smallmouth bass were estimated to have been impinged from a total of 6 fish collected in weekly 24-h samples (Jude et al. 1979a).

Catch of smallmouth bass in 1979 was below that observed in 1978. Only eight fish were processed, six from Pigeon Lake beach station V (undisturbed Pigeon Lake) and two from impingement samples. Three of the smallmouth bass seined in Pigeon Lake were adults (176-286 mm) and three were judged to be immatures (65-141 mm). One of the impinged fish was determined to a mature female (180 mm), the other measured 152 mm, but was in poor condition. From these data, only eight smallmouth bass were estimated to have been impinged in 1979.

Smallmouth bass have been uncommon in the area throughout the 3-yr study period. Since this species of bass prefers cooler water with fewer aquatic macrophytes than does the largemouth bass, they may not be susceptible to our beach seining gear. During 1979 bottom gill nets set at Pigeon Lake station M (influenced by Lake Michigan) were deleted from out sampling scheme, therefore adult fish in Pigeon Lake were only sampled during beach seining operations.

Since young of both largemouth and smallmouth bass look remarkably alike, the large impingement loss reported in 1974 and 1975 of 156 smallmouth bass may have been a result of misidentification.

Shorthead Redhorse--

Shorthead redhorses have occurred sporadically (11 collected) in the vicinity of the Campbell Plant. Nine of these fish were adults ranging from 415 to 704 mm. In 1977 a male was captured in Lake Michigan at 1.5 m. A female was taken at the same depth in Lake Michigan during 1978 and a female and two males were collected at station M (undisturbed Pigeon Lake). Station M was deleted from our sampling scheme in 1979 due to disturbances brought about by activities of Bultema Dock and Dredge Company; however, four shorthead redhorses were recovered from Lake Michigan in 1979. A male and a female were taken from 1.5-m bottom gill net sets, and a female was taken at both a 6-m and a 9-m station. Throughout the 3 yr of our study, shorthead redhorses were taken primarily at night and exclusively in bottom gill net sets in water warmer than 12.0 C.

Also in 1979 an immature shorthead redhorse 216 mm was recovered in a January impingement sample. Only one other shorthead redhorse was ever observed during impingement investigations. A single, approximately 350-mm individual was collected in 1974 by Consumers Power Company (1975).

Common Shiner--

The common shiner is apparently rare in the area of the Campbell Plant, as only two were collected during 1977-1978. Collections during 1979 were similar as only four were taken. All common shiners collected in 1979 were seined; two at station S (influenced by Lake Michigan) and two at station V (undisturbed Pigeon Lake). The occurrences exhibited no conspicuous seasonal or temperature-related trends. An additional specimen was observed in an impingement sample on 28 June resulting in a projected impingement of five common shiners during 1979. It is evident that this species only sporadically occurs in the area of the plant, possibly migrating from the upper reaches of the Pigeon River. Impingement of such low numbers of common shiners probably has no effect on the forage base of Pigeon Lake.

Silver Redhorse--

Although uncommon in the area, silver redhorses have decreased in abundance in our collections. Most individuals were adults taken only from Lake Michigan by bottom gill net or seine fished from the beach zone to 6 m. In 1977 12 silver redhorses were caught. All (except one 57-mm individual) ranged from 486 to 595 mm. Four 442- to 546-mm individuals were collected in 1978 while in 1979, only three 511- to 567-mm fish were collected. Fish were taken from July to November 1977 when water temperatures ranged from 8.2 to 21.5 C. During 1978 and 1979, silver redhorses occurred only in October and November samples when water temperatures ranged from 11.7 to 20.0 C.

Logperch--

Prior to the 1979 field season, logperch were observed exclusively in impingement samples (Consumers Power Company 1975; Zeitoun et al. 1978; Jude et al. 1978, 1979a). Six of the seven fish impinged during these years ranged from 92 to 124 mm and were probably adults. During October 1979 an 86-mm male logperch was removed from an impingement sample. This was the only logperch in impingement samples during 1979; however, three logperch were estimated to have been impinged for the year.

Although logperch were never collected in the field near the Campbell Plant prior to 1979, these demersal fish were seen near the intake jetties and among the riprap during diving operations. Also three 40- to 46-mm logperch were seined during the day in July 1979 at beach station V (undisturbed Pigeon Lake).

Logperch have always been considered rare in the study area and their appearance in an undisturbed area of Pigeon Lake was unexpected. These young fish may have been forced from the jetty area by the aggressive actions of territorial or spawning adults which colonized the riprap. Those logperch impinged may be adults which have strayed from the jetties area into the intake current. In 1978 a larval logperch was recovered at south transect station E (12 m, south), but no logperch larvae were found in 1979 samples.

Bowfin--

During 1979 only three bowfins were collected; all in Pigeon Lake. Of these, one was seined at night at beach station S (influenced by Lake Michigan) in July; the other two were caught during August at beach station V (undisturbed Pigeon Lake), one at night and one during the day. All three bowfins were males (515-584 mm) showing slight or moderate gonad development. More bowfins (10) were caught at beach station S and V in 1978 than in 1979 (3), but only two were found at these stations in 1977. The 1977 field sampling indicated that bowfins were able to avoid seines and may be more effectively sampled by bottom gill nets. Gillnetting in Pigeon Lake was, however, substantially reduced in 1978 and not performed at all in 1979. An appreciable number of bowfins were sighted while electrofishing in November 1979 suggesting that bowfin populations remained at the same level during 1977-1979. Bowfins were caught in water temperatures of 14.7-21.3 C.

Three bowfins were removed from the traveling screens during 1979 which corresponded to a total number impinged of 14 for the year. All three impinged bowfins were large specimens 510, 458 and 473 mm collected respectively in March, April and August.

Blackside Darter--

The blackside darter is a stream species preferring quiet, clear pools with bottoms of sand and gravel, but is tolerant of turbid waters (Scott and Crossman 1973). No blackside darters were collected in 1977; one immature (29 mm) was seined at station S (the Lake Michigan influenced beach station in

Pigeon Lake) in July 1978. Two individuals were seined during 1979; one immature (51 mm, 1.0 g) at station V (undisturbed Pigeon Lake) in July and an adult male (57 mm, 1.9 g) at station S in September. These fish caught in Pigeon Lake may just be strays from Pigeon River; SCUBA divers observed considerable numbers of blackside darters in the Pigeon River within 1 km of beach station T (influenced by Pigeon River) in September 1978. Supplementary seining during November 1979 at a Pigeon River site over 4 km from station T showed the blackside darter to be fairly common. Individuals collected ranged from approximately 25 to 80 mm.

Yellow Bullhead--

Only two yellow bullheads, were collected in 1979. A 249-mm female was caught in a night seine haul during August at station V (undisturbed Pigeon Lake). One YOY yellow bullhead (87 mm) was collected in a night plankton net tow at beach station S (influenced by Lake Michigan) during August. Yellow bullheads appeared to avoid deep water and have never been caught at open water station M (influenced by Lake Michigan). Seine catches at beach station S (influenced by Lake Michigan) and V suggested yellow bullhead populations are declining in the western portion of Pigeon Lake. Fifteen and seven yellow bullheads were caught at these stations in 1977 and 1978 respectively. No yellow bullheads were caught in seines at station S and, as previously mentioned, only one was found at station V in 1979. Only five yellow bullheads were estimated impinged in 1979. Slightly more (20) were impinged during 1978.

Goldfish--

The goldfish is native to eastern Asia, but was introduced into the United States and spread throughout the country (Scott and Crossman 1973). Goldfish prefer shallow, heavily vegetated, warm-water areas and in the Great Lakes region are abundant in Lake Erie, Lake St. Clair and the Detroit River.

A few goldfish have been collected every year (1977-1979) from Pigeon Lake. In 1977 two YOY goldfish were seined at Pigeon Lake station S (influenced by Lake Michigan) during August and an adult female was seined at station V (undisturbed Pigeon Lake) in 1978 (Jude et al. 1979a). Also during 1978, an immature goldfish was seined at beach station Q (south discharge); this fish may have been a stray from a population of goldfish in the warm water of the discharge canal.

In 1979 an adult female (297 mm, 546.1 g) was seined at station V (undisturbed Pigeon Lake) at night in September and an immature (45 mm) was also seined at station V, at night, in October. Only a few goldfish were impinged at the Campbell Plant. Eight were observed in impingement samples during June to December, 1977 (Zeitoun et al. 1978), none were collected in 1978, and four goldfish (65-234 mm) were collected in 1979. The largest of these four was a female with spent ovaries caught in May which suggests spawning took place in the study area during May. A few goldfish were seen

during electroshocking activities in Pigeon Lake from 1977 to 1979. Almost all goldfish observed were "wild" olive-green in color; one gold-colored individual was sighted.

Green Sunfish--

One YOY green sunfish was caught in adult sampling gear during 1979. Surprisingly, this fish was trawled in Lake Michigan (at the south reference transect) from a depth of 9 m during November. No green sunfish were collected during 1977 while 46 were estimated to have been impinged during 1978 (Jude et al. 1978, 1979a). Evidently then, green sunfish are uncommon in the Pigeon Lake area and the appearance of a YOY in Lake Michigan is probably best described as incidental.

Lake Sturgeon--

Only one lake sturgeon was caught during our 1979 sampling. This specimen (795 mm) was gillnetted at station L (6 m, south discharge) in May at a water temperature of 12.0 C. Age-at-length estimates given by Scott and Crossman (1973) suggest that this specimen was approximately 15-yr old. Since this species is currently listed as threatened, we returned the specimen to the water alive. In our sampling during 1977-1979, only two lake sturgeons have been caught, confirming their scarcity in the area of the Campbell Plant. During 1974, only three lake sturgeons were near the Cook Plant (Jude et al. 1979a), confirming their scarcity in southeastern Lake Michigan. Historically, this species has exhibited the most abrupt decline of any species in Lake Michigan (Wells and McLain 1973). The primary reason was overfishing and possibly degradation of spawning streams. It is doubtful whether the warm water discharges in Lake Michigan are effecting a further demise of the species, however intakes in Lake Michigan do on rare occasions impinge lake sturgeons.

Grass Pickerel--

Only one grass pickerel (130 mm) was caught in Pigeon Lake during 1979. Observations made while electroshocking in 1978 and 1979 suggest this species is common in the undisturbed areas of Pigeon Lake and is showing increased abundance in the more river-influenced areas of Pigeon Lake. In contrast with what was found during 1978 (45 impinged), we found no grass pickerel in impingement samples in 1979. It is likely that this species is subject to only sporadic and minimal impingement loss due to random movement into the intake area.

Black Bullhead--

Black bullheads were less commonly caught during field sampling than other bullhead species. Only one black bullhead was collected in 1979. Two black bullheads were caught in 1978 and 17 in 1977. The black bullhead collected in 1979 was seined at night at beach station V (undisturbed Pigeon Lake) during May; water temperature was 14.7 C. This specimen was a spent female approximately 245 mm. Gonad data of black bullheads collected during

1977-1979 indicated that spawning took place from May to July in Pigeon Lake. Breder and Rosen (1966) reported black bullheads spawn during May-June in Illinois and June-July in Wisconsin.

During 1979 one yearling black bullhead (84 mm) and 10 adults (130-237 mm) were removed from the traveling screens. The total number of black bullheads impinged during 1979 was estimated at 74. Adults were collected in April, June, July, November and December and yearlings were found in January. Impingement of black bullheads took place mostly during darkness. Larger numbers of black bullheads (130) were impinged during 1978 than in 1979. Unlike 1978, more black bullheads (74) were impinged in 1979 than brown bullheads (26) and yellow bullheads (5).

Burbot--

In contrast to collections in 1977 and 1978, no adult burbot were caught in 1979. Gill net sampling in Pigeon Lake and Pigeon River during December and February indicated that some burbot do move into these areas during winter months. Spawning undoubtedly occurred since larval burbot were observed in April and May entrainment samples (see FISH LARVAE AND FISH EGGS - Burbot). Impingement losses of burbot in 1979 (estimated total of 126) were comparable to that of 1978 (estimated total of 121). A tendency for this species to be impinged at greater rates during colder months (December-March) was evident upon examination of 1978-1979 data.

Walleye--

No walleyes were collected in field samples during 1979, while impingement samples accounted for 11. The estimated number of walleyes impinged during 1979 was 75 fish while in 1978, 115 were impinged. During 1978, 7 walleyes were caught in Lake Michigan field samples, while impingement samples accounted for 15 fish. The fact that walleyes were impinged during colder months (Appendix 9) suggests an attraction for the warm water discharge of the plant. Supplementary sampling in the discharge canal documented their presence in that area.

Although not abundant in southeastern Lake Michigan large numbers of walleyes are planted in the Muskegon River system and in Lake Macatawa (R. Lincoln, personal communication, Michigan Dept. of Natural Resources, Grand Rapids, Mich.). Natural spawning of walleyes does occur in eastern Lake Michigan.

Quillback--

Localized populations of quillbacks in the western drainage basin of Lake Michigan have been reported in the Grand and Macatawa Rivers in Michigan (Becker 1976). Our data indicate that an additional local population exists in the discharge canal at the Campbell Plant. Observations during July 1978 and 1979 of large schools (20-30 individuals/school) of YOY quillbacks suggest that reproduction is taking place in the discharge canal. Field collections in the vicinity of the plant indicate only an occasional dispersal out of the

discharge canal (or perhaps the Grand River) as only four quillbacks were caught in Lake Michigan and only one was caught in Pigeon Lake during 1977-1979. Impingement of this species is apparently restricted to colder months and may be related to the opening of recirculation gates in the present discharge canal. Opening of these gates allows fish to pass from the discharge canal into the intake forebay, where they could possibly be impinged. This mechanism is also suspected of being the cause for abundant gizzard shad impingement in colder months (December-March) since none were collected in Pigeon Lake.

Impingement loss of this species during 1979 (an estimated 37 impinged) was less than 1978 levels (an estimated 173 impinged). We are unsure what effects future design changes of the plant will have on the impingement loss of this species, but sporadically high (108 was the maximum per month reported in March 1978) impingement could be expected in colder months if no design changes are effected.

Sea Lamprey--

Two sea lampreys were collected in impingement samples taken at the Campbell Plant in 1979. A 302-mm lamprey was collected in March and a 505-mm lamprey was taken in November. The 505-mm specimen was a female with well developed gonads. Expanding this number of a total number of sea lampreys impinged over the entire year showed that 11 sea lampreys were lost to impingement. No sea lampreys were caught in 1979 field sampling in Lake Michigan or Pigeon Lake.

Flathead Catfish--

The flathead catfish was not known from collections during 1977-1978. The occurrence of a solitary specimen (375 mm, 519.3 g) in an impingement sample in April 1979 gives indication that it is rare in the area of the Campbell Plant. This species is reported to inhabit the Grand River and Black River basins, which are north of the plant (Becker 1976).

IMPINGEMENT

Introduction

Impingement samples were collected weekly from 1 January 1979 to 31 December 1979 at the Campbell Plant. Data from these impingement collections were extrapolated to give estimated monthly total impingement for all species (Appendix 9 and Table 39). Data were evaluated in terms of seasonal changes in species composition and abundance and their relation to species abundance in the vicinity of the Campbell Plant. Possible effects of impingement on fish populations of Lake Michigan and Pigeon Lake are discussed under individual accounts of juvenile and adult species.

Table 39. Total number of fish impinged by species during 1979 at the J. H. Campbell Plant, eastern Lake Michigan. Numbers were extrapolated to monthly totals based on one 24-h impingement sample collected each week.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
Alewife	1943	448	6		595	8855	9244	2712	9185	11346	25070	1968	71372
Gizzard shad	20872	7392	4030	510	6		6	319	180	899	4065	2294	40573
Spottail shiner	325	266	1571	695	279	285	1472	232	65	114	600	207	6111
Smelt	3			20	21	15	21	914	305	499	585	130	2513
Trout-perch	294	369	341	80	15		6		35	124	530	269	2063
Yellow perch	282	98	341	255	83	35	31	31		9	135	139	1439
Largemouth bass	220	19	21	35				34		716	95	62	1202
Black crappie	96	28	21	135	15	5	31	9		15	15	62	432
Northern pike	3		93	45		5	31					108	285
White sucker		14	114	75	6							6	215
Golden shiner	21		52	120								6	199
Bluegill	9			5						71	45	15	145
Chinook			21	60	15		15	3		3	20	6	143
Burbot	40	42	15	20	6					3			126
Slimy sculpin	9	5	6	75							5		100
Ninespine stickleback			15	5	31	15	15			3		6	90
Walleye	15	14	15									31	75
Black bullhead	3			30		15	6				5	15	74
Unidentified coregonidae									15	3	50		68
Emerald shiner		5	46	5	6				5				67
Channel catfish	21		6	15					5			6	53
Pumpkinseed	3			35						3	5		46
Tadpole madtom						5	6	15	5		5	6	42
Quillback												37	37
Mottled sculpin		5	6	20							5		36
Brown trout		14		15				3					32
Fathead minnow	3		6	20									29
Rock bass		5				5		3			15		28
Brown bullhead			6							9	5	6	26
Coho salmon	3			5	6			3		9			26
Lake trout					6				5	3	5	6	25
Goldfish	3		6	5	6								20
Bowfin			6	5				3					14
Sea lamprey			6								5		11
Smallmouth bass						5				3			8
Rainbow trout												6	6
Carp											5		5
Common shiner						5							5
Flathead catfish				5									5
Yellow bullhead											5		5
Logperch										3			3
Longnose sucker								3					3
Shorthead redhorse	3												3
TOTALS	24171	8724	6750	2295	1096	9250	10884	4284	9805	13835	31275	5391	127760

General Trends

Alewife was the most common species impinged during 1979, comprising 54.3% of total yearly impingement losses. During June and July, large numbers of adult alewives (size range 160-210 mm) were impinged. These months corresponded with the peak spawning period for alewives when they move inshore in Lake Michigan and into Pigeon Lake. During September, October and November large numbers of YOY alewives (25-65 mm) were impinged.

Gizzard shad was the second-most numerous species in impingement samples, representing 33.3% of the total collected. Peak impingement occurred during January and February. Most gizzard shad collected during those months were juveniles (120-180 mm). November and December impingement samples contained moderate numbers of gizzard shad. Most were small (55-85 mm) fish.

Spottail shiners represented 4.5% of the total impingement collections and rainbow smelt comprised 2.1% of the total. Trout perch, yellow perch and largemouth bass comprised 1.6, 1.1 and 1.0%, respectively, of total impingement collections.

A summary of impingement losses during 1977, 1978 and 1979 (Table 40) reveals that gizzard shad and alewife were the most commonly impinged species representing 54% and 38%, respectively, of the total impingement loss for these 3 yr. In 1979, the plant impinged 127,760 fish which is lower than the 1978 total (136,737), but almost half the 1977 (13 June-22 December) level of 252,674 fish reported by Zeitoun et al. (1978).

Monthly Impingement Results

January--

As in 1978, juvenile gizzard shad (140-180 mm) and alewife (60-80 mm) made up the bulk of impingement samples in January 1979 (Appendix 8). Gizzard shad comprised 86.11% of the monthly sample (20,872 fish projected total); alewives made up 8.03% (1943 fish projected total). Spottail shiners and trout-perch made up 1.36 and 1.23% of the monthly total. Most likely, gizzard shad and alewives enter the intake forebay from the discharge canal through a gate between the two which allows warm discharge water into the intake forebay to prevent ice formation. Large numbers of gizzard shad and alewives inhabit the discharge canal during colder months.

February--

Juvenile gizzard shad (120-170 mm) were once again the most common species observed in impingement samples making up 84.62% of the monthly sample (Appendix 8). Alewives, trout-perch, spottail shiners and yellow perch made up 5.13, 4.25 and 1.12% of the monthly totals. Projected numbers of gizzard shad, alewife, trout-perch, spottail shiner and yellow perch for the month were 7392, 448, 369 and 98. Similar results were observed in February 1978.

Table 40. Total number and weight (kg) of fish impinged by species during 1977, 1978 and 1979 at the J. H. Campbell Plant, eastern Lake Michigan. Numbers were extrapolated to monthly totals based on one 24-h impingement sample collected each week, then added to get a yearly total.

Species	1977*		1978		1979	
	No.	Wt. (kg)+	No.	Wt. (kg)	No.	Wt. (kg)
Gizzard shad	165,219	1327.20	74,727	1842.15	40,573	2124.30
Alewife	81,397	2341.50	45,722	1145.41	71,372	1860.40
Spottail Shiner	3,265	18.90	5,673	60.78	6,111	146.60
Trout-perch	604	3.50	1,283	16.61	2,063	20.60
Yellow perch	303	8.40	1,519	42.76	1,439	39.20
Rainbow smelt	282	1.19	1,333	11.59	2,513	27.20
Ninespine stickleback	200	0.06	331	1.01	90	<0.01
Brown bullhead	165	0.58	225	10.06	26	3.00
Carp	185	0.24	25	7.70	5	<0.01
Longnose sucker	132	0.03	6	0.03	3	<0.01
Channel catfish	132	4.27	100	7.44	53	5.90
Rock bass	122	1.89	21	1.20	28	<0.01
Rainbow trout	108	7.00	13	1.68	6	18.50
Largemouth bass	89	1.61	3,061	23.34	1,202	27.70
Bluegill	79	1.40	183	5.02	145	<0.01
Black crappie	74	1.05	406	8.39	432	<0.01
Northern pike	59	1.19	68	19.20	285	9.00
Goldfish	39	0.18			20	<0.01
Pumpkinseed	34	0.04	115	1.74	46	<0.01
Yellow bullhead	29	7.00	20	2.60	5	<0.01
White sucker	26	9.94	199	80.25	215	145.00
Warmouth	24	0.43	7	1.45		
Lake trout	20	14.00	7	31.42	25	82.10
Coho salmon	18	0.06	334	16.03	26	8.90
Black bullhead	16	0.04	136	6.92	74	2.90
Logperch	12	0.06	50	0.44	3	<0.01
Sea lamprey	12	1.61	15	3.02	11	<0.01
Burbot	10	0.24	121	57.67	126	38.40
White crappie	9	1.08				
Tadpole madtom			45	0.20	42	<0.01
Quillback			173	15.07	37	3.00
Chinook salmon			143	7.60	143	32.80
Walleye			115	17.96	75	30.00
Emerald shiner			72	0.49	67	<0.01
Unidentified coregoninae			69	0.24	68	<0.01
Slimy sculpin			66	0.41	100	<0.01
Brown trout			64	14.04	32	11.90
Green sunfish			46	1.47		
Grass pickerel			45	1.88		
Smallmouth bass			41	4.24		
Creek chub			28	1.70		
Bowfin			27	28.79	14	15.10
Mottled sculpin			22	0.29	36	<0.01
Golden shiner			21	0.12	199	<0.01
Pirate perch			21	0.37		
Lake chubsucker			12	0.36		
Chestnut lamprey			7	0.07		
Fathead minnow			7	0.04	29	<0.01
Fourhorn sculpin			7	2.00		
Bluntnose minnow			6	0.01		
Smallmouth bass					8	<0.01
Common shiner					5	<0.01
Flathead catfish					5	2.90
Shorthead redhorse					3	<0.01
TOTAL	252,664	3754.69	136,737	3,503.26	127,760	4655.61

*Data from June to December only; taken from Zeitoun et al. (1978).

+Actual weight of fish removed from weekly 24-h intake screen samples was multiplied by 7 to give total extrapolated weight for June to December 1977.

March--

Juvenile gizzard shad (120-180 mm) were the most common species in March impingement samples followed by spottail shiners, yellow perch, trout-perch, white suckers and northern pike (Table 39). Estimated numbers impinged during the month for the above species were: 4030, 1571, 341, 341, 114 and 93. Numbers of gizzard shad impinged were considerably less than January losses.

April--

Small adult spottail shiners (90-120 mm) were the most frequently impinged fish in April accounting for 29.90% (695) of the monthly total. Numbers of gizzard shad impinged declined sharply from March levels. Only 510 (projected total) were impinged in April. Closing of the gate between the intake forebay and the discharge canal is most likely responsible for the reduction in gizzard shad impingement. An estimated 255 small yellow perch (80-140 mm) were impinged in April. Golden shiners, trout-perch, white suckers and chinook salmon made up 5.14, 3.54, 3.22 and 2.57% of the April total.

May--

As was observed in 1978, the lowest total number of impinged fish for any month occurred during May. Over 53% of the monthly total was made up of alewives (170-180 mm). Spottail shiners and yellow perch made up 25.0 and 7.6% of the monthly total (Table 39).

June--

Adult alewives (160-220 mm) (95.5% of the total catch) were the most frequently collected species during impingement sampling in June. Adult alewives comprised 93% of the total impingement collection in June 1978. An estimated 8855 alewives were collected in June 1979 which is a sizeable reduction in catch from the 14,490 collected during June 1978. The high incidence of impinged alewives in June is most likely due to spawning activity in Pigeon Lake and Lake Michigan.

July--

Alewife was the most abundant species impinged with an estimated 9244 impinged during July. Most of these fish were adults (160-220 mm) (Appendix 8), part of the population of spawning alewives that was residing in Pigeon Lake. Spottail shiners were impinged in moderately high numbers in July. An estimated total of 1472 spottails was impinged with most fish in the 90-130-mm length intervals. Spottail shiners were also abundant in field samples in Pigeon Lake and Lake Michigan. In July 1978, alewives and spottail shiners were also the most frequently impinged species.

August--

Alewife was the most numerous species impinged this month with an estimated 2712 alewives lost to impingement. Numbers of adult alewives impinged declined in August (Table 39). YOY alewives (20-60 mm) appeared in impingement samples late in August. Adult alewives were probably moving out of Pigeon Lake after spawning which would account for the lower impingement rate.

Rainbow smelt was the second-most frequently impinged species with an estimated total of 914 fish impinged. Most smelt impinged were in 20-50-mm length intervals (Appendix 8). A small number of adults, which most likely came from Lake Michigan due to a mild upwelling which cooled the inshore water in August (see ADULT AND JUVENILE FISH - Rainbow Smelt), were impinged. Other species impinged in moderate numbers were gizzard shad (319 estimated impinged) and spottail shiners (232 estimated impinged).

September--

Alewife again was the most frequently impinged species this month with an estimated total of 9185. Most were YOY alewives (20-80 mm) with few adults impinged. Adults had probably moved out of Pigeon Lake by September. Seining in Pigeon Lake did not capture large numbers of YOY; however, YOY may have moved slightly offshore making them not susceptible to seining, but vulnerable to impingement.

Rainbow smelt was the second-most frequently impinged species (estimated 305 impinged). All other species were impinged in relatively low numbers (Appendix 9).

October--

YOY alewives (30-80 mm) again dominated collections with an estimated 11,346 alewives impinged in October. YOY were very abundant in Lake Michigan field samples this month. Few alewives were taken in Pigeon Lake seines indicating that YOY alewives were probably inhabiting offshore areas.

Gizzard shad was the second-most frequently impinged species with an estimated 899 fish lost to impingement. Most fish were in 60-90-mm length intervals.

Largemouth bass were impinged in moderately large numbers in October (an estimated total of 716 fish). Most fish were in 70-110-mm length intervals. All other species were impinged in relatively low numbers (Appendix 9 and Table 39).

November--

Impingement this month was the highest of the entire year (Table 39) with an estimated total of 31,275 fish impinged. Alewife was the most abundant species (estimated total of 25,070 fish) and gizzard shad was second-

most abundant (4065). All alewives were YOY (30-90 mm) as were most gizzard shad (60-100 mm). The abundance of YOY alewives in impingement samples may reflect two sources for these fish. As in October, YOY were very abundant in Lake Michigan field samples. Although not collected in Pigeon Lake seines, YOY alewives were probably residing in deeper areas of Pigeon Lake. This large impingement of alewives also corresponded to the opening of the connecting gate between the discharge and intake forebays. Many YOY alewives and gizzard shad may have been residing in the discharge canal.

Other species which were impinged in moderate numbers were spottail shiner (600 fish), rainbow smelt (585) and trout-perch (530). Few fish of other species were impinged (Table 39).

December--

Impingement this month was down from November with an estimated total of 5391 fish impinged. Gizzard shad were most frequently impinged with an estimated 2294 fish lost. Alewives were second-most numerous with 1968 fish impinged. Trout-perch and spottail shiners were impinged in moderate numbers (269 and 207, respectively). All other species were impinged in relatively low numbers (Table 39).

Other Considerations

Diel patterns of impingement were examined for the three most frequently impinged species:alewife, gizzard shad and spottail shiner (Table 41). Both alewife and gizzard shad showed lowest impingement rates at night. Spottail shiners did not appear to vary appreciably in rates at which they were impinged.

Table 41. Total number of fish collected during each impingement sampling period in 1979 at the J. H. Campbell Plant, eastern Lake Michigan. Numbers in parentheses are rates of impingement, given in number of fish impinged per hour.

	Period (duration in h)			
Species	Day (8 h)	Dusk (5 h)	Night (7 h)	Dawn (4 h)
Alewife	3243 (1.11)	2472 (1.35)	1887 (0.74)	1724 (1.18)
Gizzard shad	2593 (0.89)	1683 (0.92)	879 (0.34)	892 (0.61)
Spottail shiner	209 (0.07)	211 (0.12)	268 (0.10)	126 (0.09)

Impact of Impingement

Impingement of fish at the J. H. Campbell Plant is believed to have little impact on species in the area when impingement numbers are compared to the abundance and distribution of these species in Lake Michigan and the discharge canal. Alewife was the most frequently impinged species at the Campbell Plant. However, when the estimated total number of alewives impinged

at the Campbell Plant was compared to an estimated population of alewives in the southern basin of Lake Michigan (Brandt 1978), these impinged fish represented 0.01% of the southern basin population. Impinged gizzard shad probably originate from the substantial population known to inhabit the discharge canal (Jude et al. 1979a). Only 37 specimens were collected in field samples and months of high impingement did not correspond with months of large field catches.

Game fish including salmonids, northern pike, largemouth bass, walleye and yellow perch were impinged in low numbers relative to their abundance in our study area. Weekly impingement sampling resulted in the collection of 21 chinook salmon, 6 coho salmon, 5 brown trout, 5 lake trout and 1 rainbow trout. Estimated total impingement values for these species for the entire year were 143, 26, 32, 25 and 6 fish, respectively. Most of the black crappies impinged were probably produced in the discharge canal and then entered the intake forebay. When the gate between the intake forebay and discharge canal was closed black crappie impingement was almost negligible.

During 1979, an estimated 285 northern pike were impinged. Studies in Pigeon Lake in 1978 estimated that a population of 690 northern pike greater than 299 mm and 1259 fish between 175 and 299 mm existed in the lake (Jude et al. 1979a). Of those northern pike impinged, approximately 7 were greater than 299 mm and 75 were between 175 and 299 mm. These numbers represent 1% and 6%, respectively, of the estimated population of these size groups.

An estimated total of 1202 largemouth bass were impinged in 1978. Six of these were greater than 219 mm and six were between 175 and 219 mm. Population studies done in 1978 estimated that the population of largemouth bass greater than 219 mm was 290 fish and the population between 175-219 mm was 842 fish (Jude et al. 1979a). Those 175-219-mm largemouth bass impinged represented 2% of the population while those greater than 219 mm comprised 0.7% of its respective 1978 population. Most largemouth bass impinged in 1978 were YOY and the number impinged in 1979 (1202) was down from 1978 when over 3000 were lost (Jude et al. 1979a). For more detail on the impact of impingement on these and other species, refer to individual species discussions in the ADULT AND JUVENILE FISH section.

FISH LARVAE AND FISH EGGS

In recognition of the extreme importance and fragility of the egg and larval stages of fishes, an intensive sampling scheme was continued for a third season in the vicinity of J. H. Campbell Plant. The monitoring of year-to-year changes in larval fish abundances is the first step in analyzing the possible effects of entrainment losses on the fish populations in any aquatic habitat.

The goals and objectives of this study, though somewhat refined, are basically the same as those set forth in previous reports (Jude et al. 1978, 1979a). Primary in our consideration was the gathering of data to determine what impacts were being made on larval fish populations by the present cooling water system of the Campbell Plant.

Secondary objectives included:

1) Continue to describe what species were present and in what abundance, as well as their spatial (vertical and horizontal) and temporal (seasonal and diel) distribution
2) Determine which species utilized Pigeon Lake and Lake Michigan in the Port Sheldon area as spawning and nursery grounds, and verify the extent of the utilization
3) Continue to gather information to correlate the appearance of fish larvae in field samples with occurrence in entrainment samples
4) Completion of information about life cycles, including spawning times and locations
5) Provide background data for evaluating the effectiveness of wedge-wire screens used on the Unit 3 offshore intake.

Data collected during 1977-1978 have documented considerable variability in seasonal occurrences and abundances of larval fish in the vicinity of the plant. It becomes evident upon examination of the data that trends in larval fish distributions only became recognizable over long periods of time. Although reasons for this seem obvious, many of the factors which induce year-to-year variability in larval fish occurrences and abundance are the most difficult to document. The most influential factors affecting larval fish patterns of distribution and abundance are meteorological events. These events which ultimately effect warming trends in Lake Michigan, current patterns, upwelling of cold water and river flows, work in a complex interaction which confounds simplistic analysis.

We believe the sampling scheme employed in this study was and will continue to be successful in helping recognize trends in larval fish distribution and abundance which only become obvious over longer periods of time. The following discussion of each taxonomic group presents an in-depth review of 1979 data, closely comparing them with 1977 and 1978 data. Table 42 presents a list of all species of larvae collected near the Campbell Plant and gives common and scientific names as well as where they were collected.

Alewife

Introduction--

Previous study in the area of the Campbell Plant has documented the alewife as the most abundant species of larval fish from June to September at depths of 15 m or less. First occurrence of alewife larvae varies from year to year and is primarily related to warming trends in Lake Michigan. Threinen (1958) reported that alewife began spawning at temperatures between 12.8 and 15.5 C. Times at which these temperatures are reached in the inshore waters (less than 15 m) of Lake Michigan may vary from early June to early July. Occasional upwellings of cooler bottom water occur frequently from June to August and cause cessation of alewife spawning. Spawning activity is resumed upon subsequent warming of inshore water.

Table 42. Taxons and abbreviations for all groups of fish larvae captured from J. H. Campbell Plant study areas from January through December 1979. An L denotes presence of fish larvae in Lake Michigan, Pigeon Lake or entrainment samples and an F represents fry. Names assigned according to Bailey et al. 1970.

Scientific and Common Name	Abbreviation	Pigeon Lake	Lake Michigan	Entrainment
Atherinidae				
Labidesthes sicculus (Cope) Brook silverside	SV			L
Catostomidae				
Catostomidae spp. Unidentified Catostomidae	XS	L	L	L
Centrarchidae				
Lepomis macrochirus Rafinesque Bluegill	BG	F		
Lepomis spp. Unidentified *Lepomis*	XL	L	L	L
Pomoxis spp. Unidentified *Pomoxis*	PM	L	L	L
Clupeidae				
Alosa pseudoharengus (Wilson) Alewife	AL	L,F	L,F	L,F
Dorosoma cepedianum (Lesueur) Gizzard shad	GS	L	L	L
Cottidae				
Cottus cognatus Richardson Slimy sculpin	SS		L,F	L
Myoxocephalus quadricornis (Linnaeus) Fourhorn sculpin	FS		L	L
Cyprinidae				
Cyprinus carpio Linnaeus Carp	CP	L	L	L
Notemigonus crysoleucas (Mitchill) Golden shiner	GL	L,F		
Notropis atherinoides Rafinesque Emerald shiner	ES	L,F	L	L
Notropis hudsonius (Clinton) Spottail shiner	SP	L,F	L,F	L,F
Pimephales notatus (Rafinesque) Bluntnose minnow	BM	L,F		L
Pimephales promelas Rafinesque Fathead minnow	PP	F	F	

Table 42. Continued.

Scientific and Common Name	Abbreviation	Pigeon Lake	Lake Michigan	Entrainment
(Cyprinidae)				
Cyprinidae spp. Unidentified Cyprinidae	XM	L	L	L
Gadidae				
Lota lota (Linnaeus) Burbot	BR		L	L
Gasterosteidae				
Pungitius pungitius (Linnaeus) Ninespine stickleback	NS		L	L
Ictaluridae				
Ictalurus natalis (Lesueur) Yellow bullhead	YB	F		
Osmeridae				
Osmerus mordax (Mitchill) Rainbow smelt	SM	L,F	L,F	L,F
Percidae				
Etheostoma nigrum Rafinesque Johnny darter	JD	L,F	L,F	L
Etheostoma spp. Unidentified *Etheostoma*	XE			L
Perca flavescens (Mitchill) Yellow perch	YP	L,F	L,F	L
Percopsidae				
Percopsis omiscomaycus (Walbaum) Trout-perch	TP		L,F	L
Salmonidae				
Coregoninae spp. Unidentified Coregoninae	XC	L	L,F	L
Oncorhynchus tshawytscha (Walbaum) Chinook salmon	CH		F	
Larvae damaged beyond recognition	XP	L	L	L,F
Unidentified Pisces	XX	L		L

Our study during 1977-1978 has documented alewife spawning in Pigeon Lake as well as the discharge canal at the Campbell Plant. Indications are that spawning at these sites occurs earlier than alewife spawning in Lake Michigan due to warmer water temperatures. Some of the larvae hatched in the discharge canal may wash out into Lake Michigan accounting in part for the occurrences of alewife larvae at Lake Michigan stations during late May and early June of some years. The extent to which inland-spawned larval alewife are transported to Lake Michigan is unknown; however, in the area of the Campbell Plant spawning takes place in many large river systems (Grand River, Black River, Muskegon River) which may be contributing larvae to our sampling area.

In general, distribution of newly hatched alewives is probably dependent primarily on water currents by which the larvae are passively transported. As larvae grow, their ability to exhibit directed movement in response to environmental factors increases. Distributional tendencies of larger larvae are probably related primarily to temperature and light; however, their distribution in response to food, water current, water quality and numerous other environmental factors is largely unknown. The following pages describe the distributional patterns of larval alewives near the Campbell Plant during 1979 comparing them closely with 1977-1978 data. Comparison with our other studies aids in recognizing distributional patterns which only become evident over long periods of time.

Seasonal Distribution--

April, May--As during 1978, the first indication of alewife spawning in 1979 was during May. At this time (mid-May), low densities of larval alewife were observed at station F (15 m, south) as well as in entrainment samples (Appendixes 11 and 14). These larvae were all less than 6 mm (Fig. 64) indicating that they had hatched recently. Temperatures recorded at many of the stations during May fell within the range reported by Threinen (1958) to be conducive to alewife spawning; however, it is evident that only limited alewife spawning had occurred at this time.

June--Collections during early (4-6) June again showed that alewife spawning in Lake Michigan just prior to this time was not extensive. Highest densities of larval alewives were found at north transect stations near the discharge (Fig. 65). Two low (less than 20 larvae/1000 m^3) densities were also found at south transect D (9 m, south) and F (15 m, south). Higher densities of larvae at discharge stations may be the result of discharge canal-spawned larvae washing into the surrounding Lake Michigan habitat. As during May, length-frequency data (Fig. 64) indicated that those larvae caught in Lake Michigan in early June were newly hatched.

Despite water temperatures conducive to alewife spawning, Pigeon Lake beach stations in early June were notably devoid of larval alewife. This indicates that those larvae observed at station M (6 m, influenced by Lake Michigan) in early June, as well as those larvae entrained (Fig. 66 and Appendix 14) may have been drawn from Lake Michigan. Disturbance (extensive

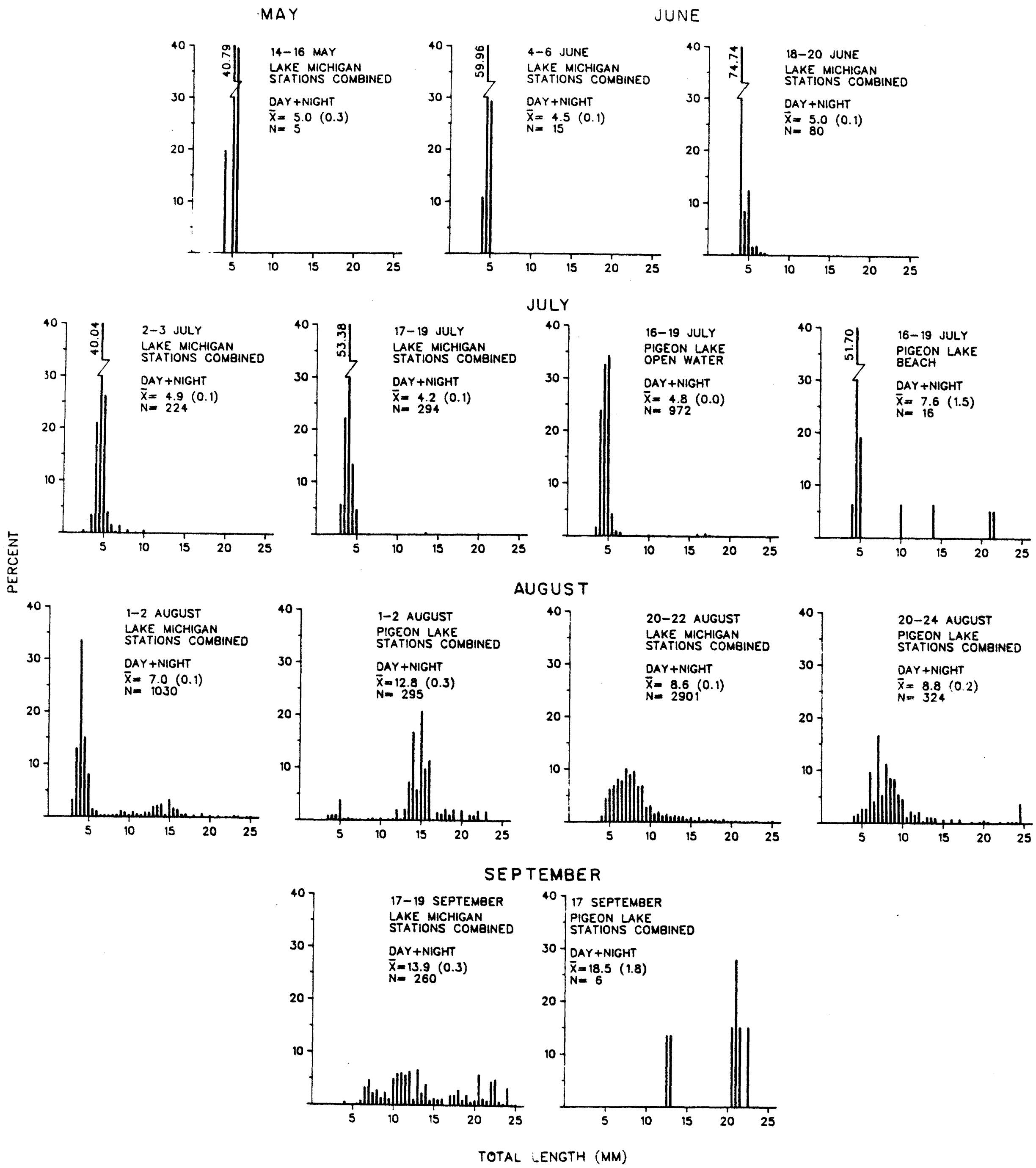


Fig. 64. Length-frequency histograms for larval alewives observed in field and entrainment samples collected during 1979 near the J. H. Campbell Plant, eastern Lake Michigan. All plankton net and sled tow samples were combined. $\bar{X}$ = mean, N = total number of larvae, standard error is given in parentheses.

ENTRAINMENT

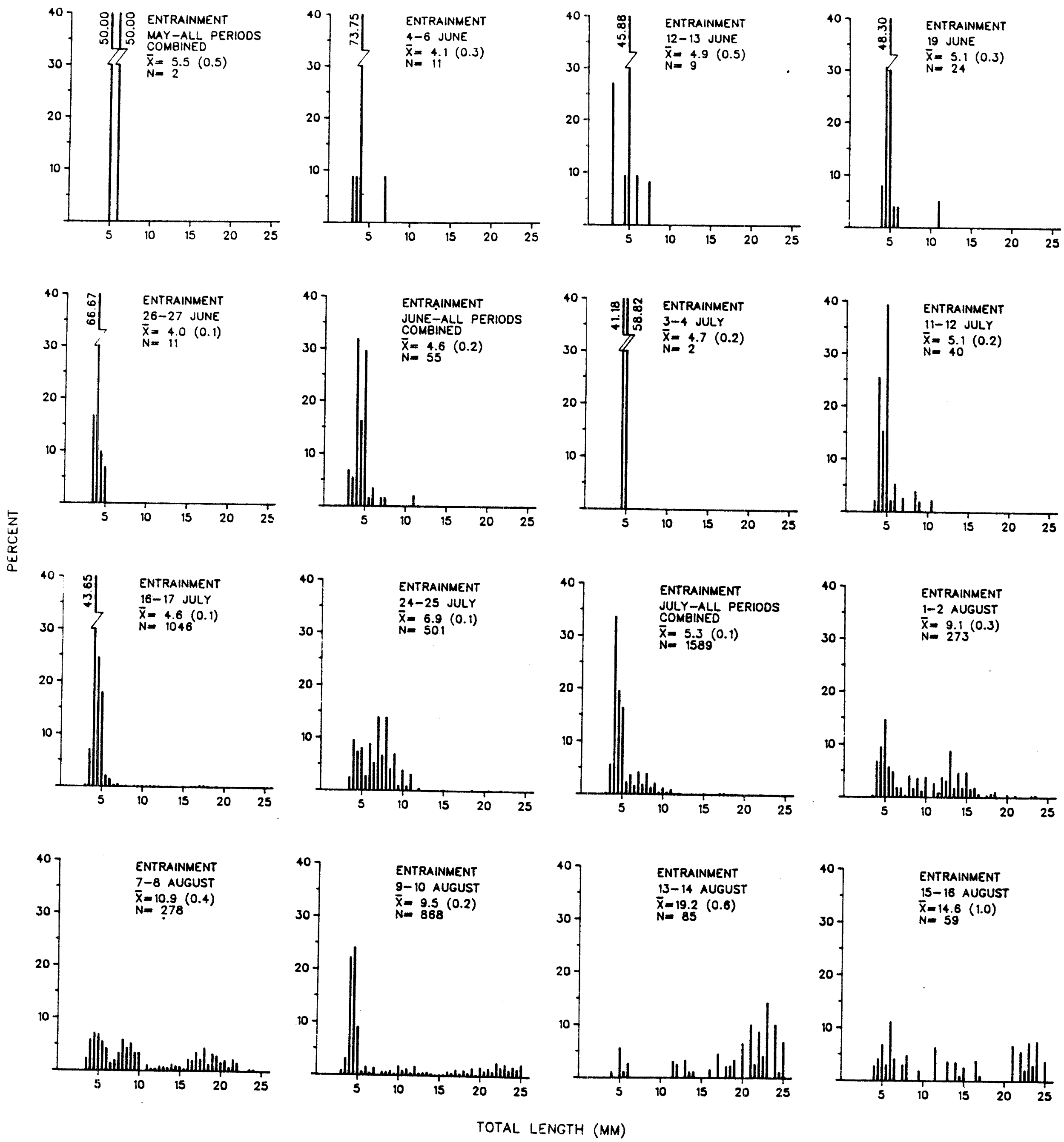


Fig. 64 . Continued.

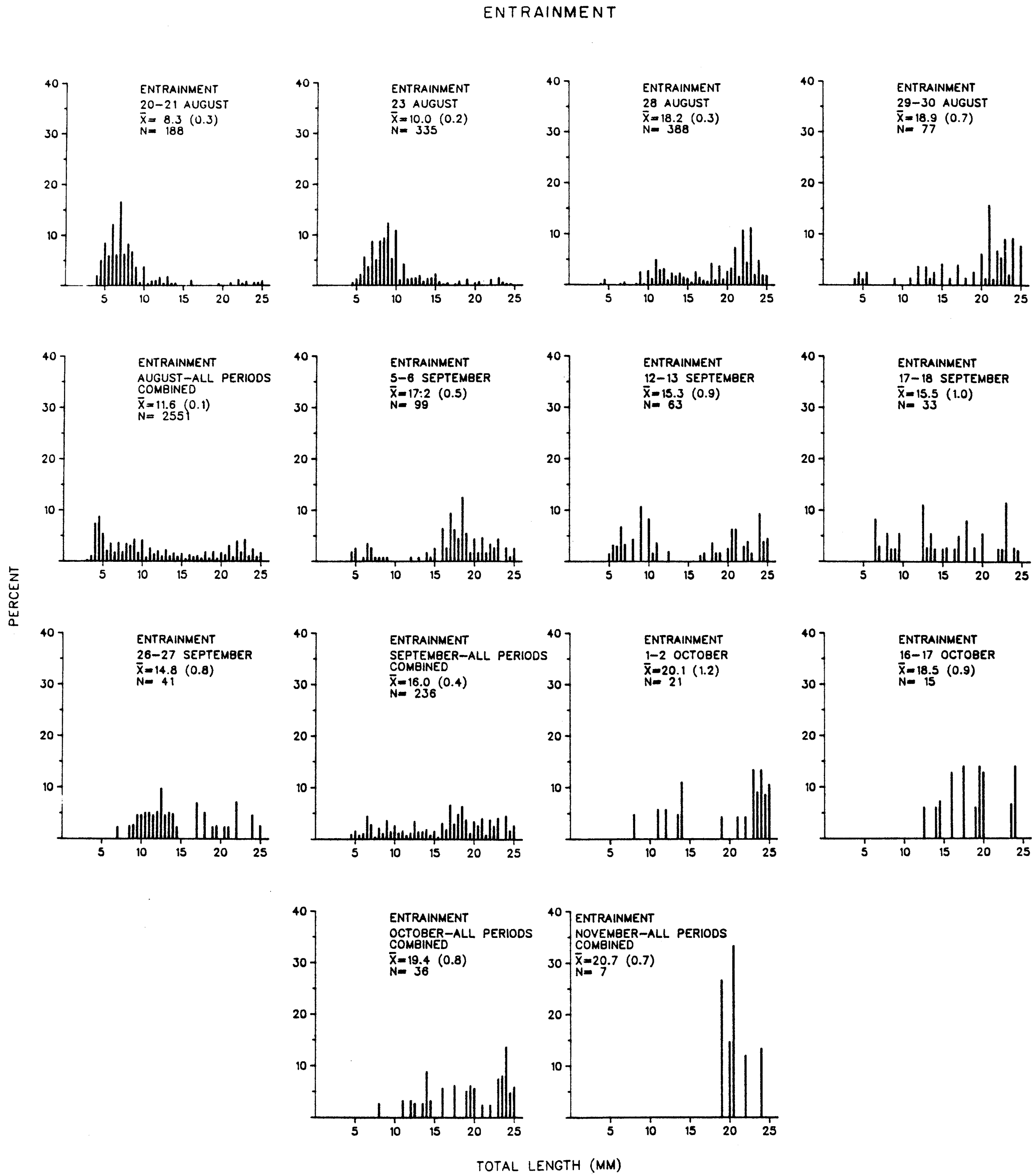


Fig. 64 . Continued.

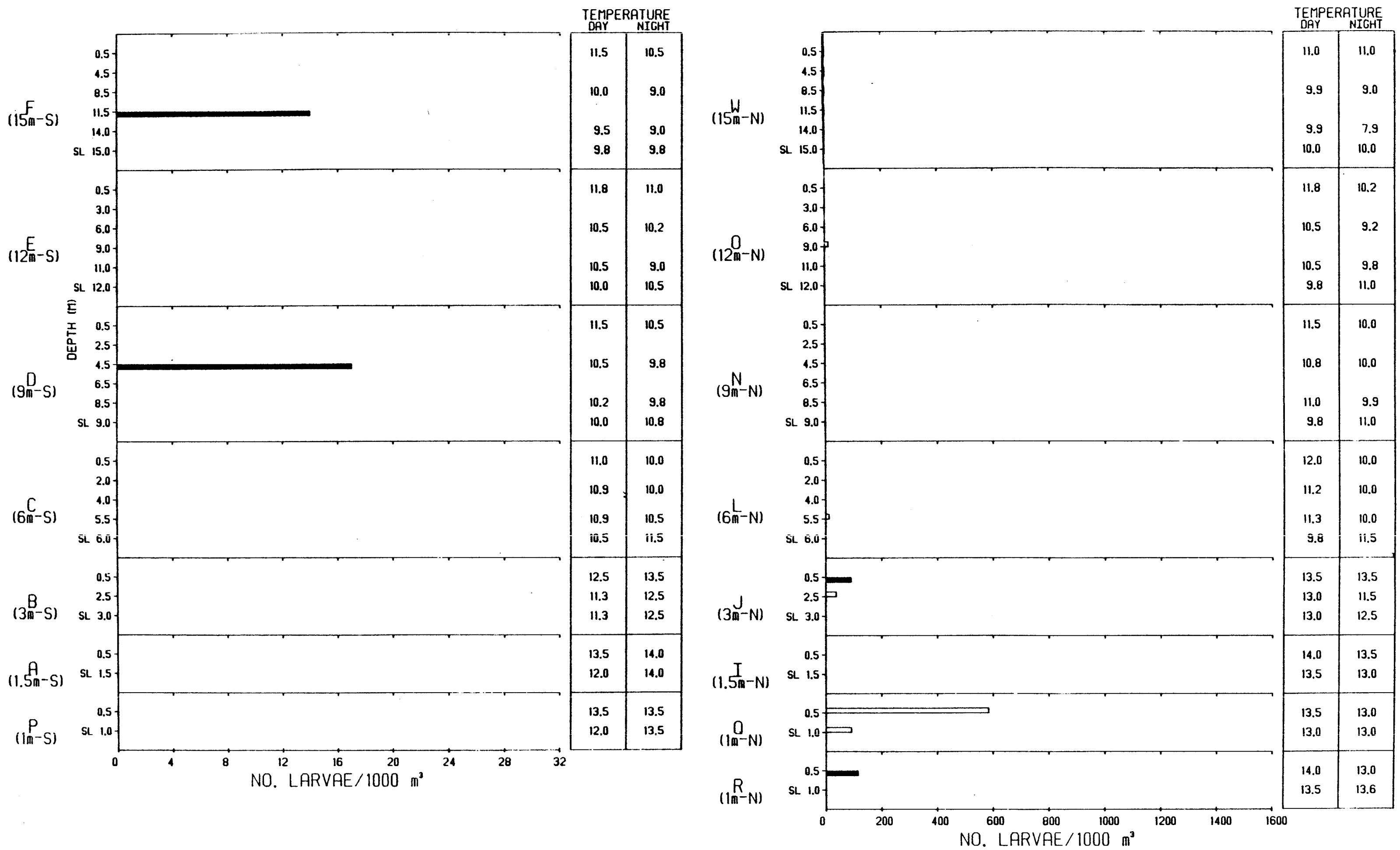


Fig. 65 . Density of larval alewives (no./1000 m^3) at Lake Michigan stations near the J.H. Campbell Plant, eastern Lake Michigan, 4-5 June 1979. □ = day, ■ = night, SL = sled, ND = no data.

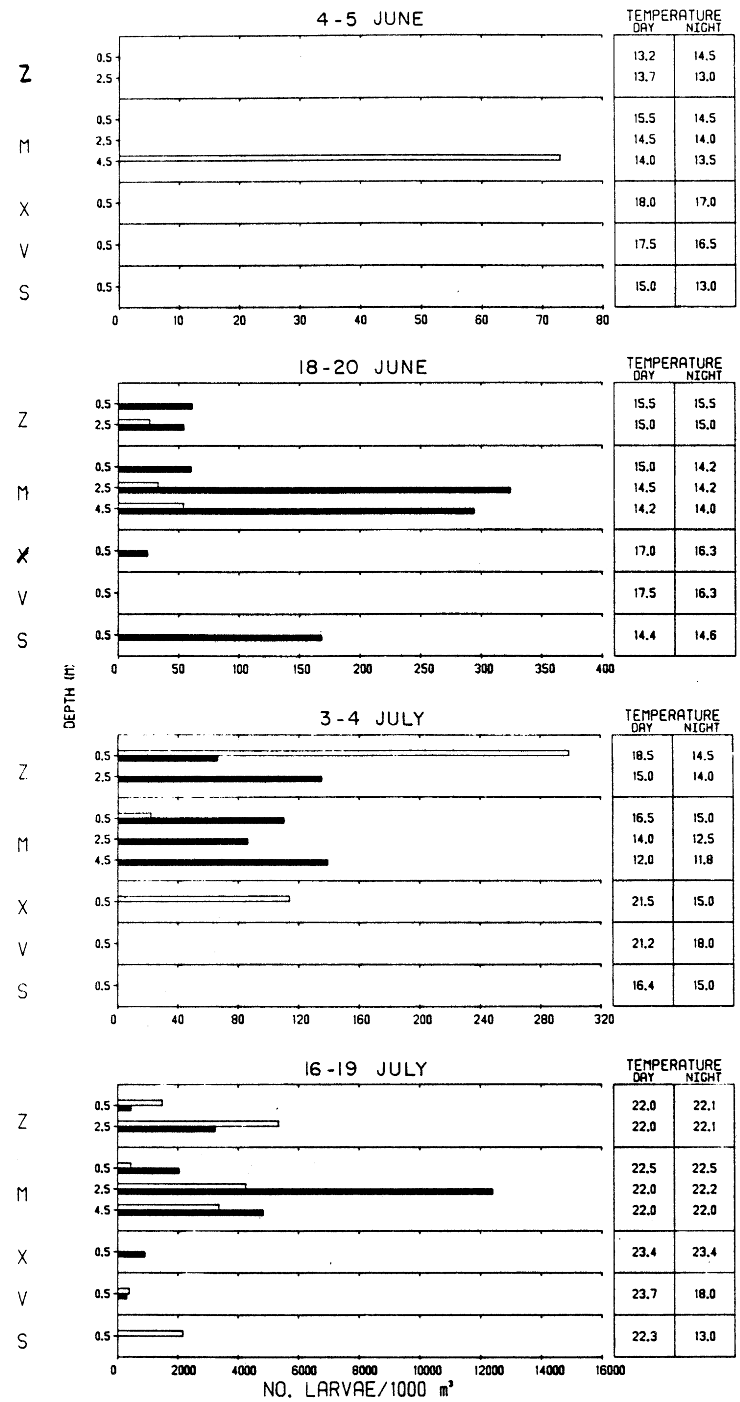


Fig. 66. Density of alewife larvae (no/1000 m^3) at Pigeon Lake and intake canal stations near the J.H. Campbell Plant, eastern Lake Michigan June to September 1979. Stations Z(intake canal), M(6 m, openwater), X(1 m, openwater), V(beach, undisturbed) and S(beach, Lake Michigan influenced) are shown. □ = day, ■ = night.

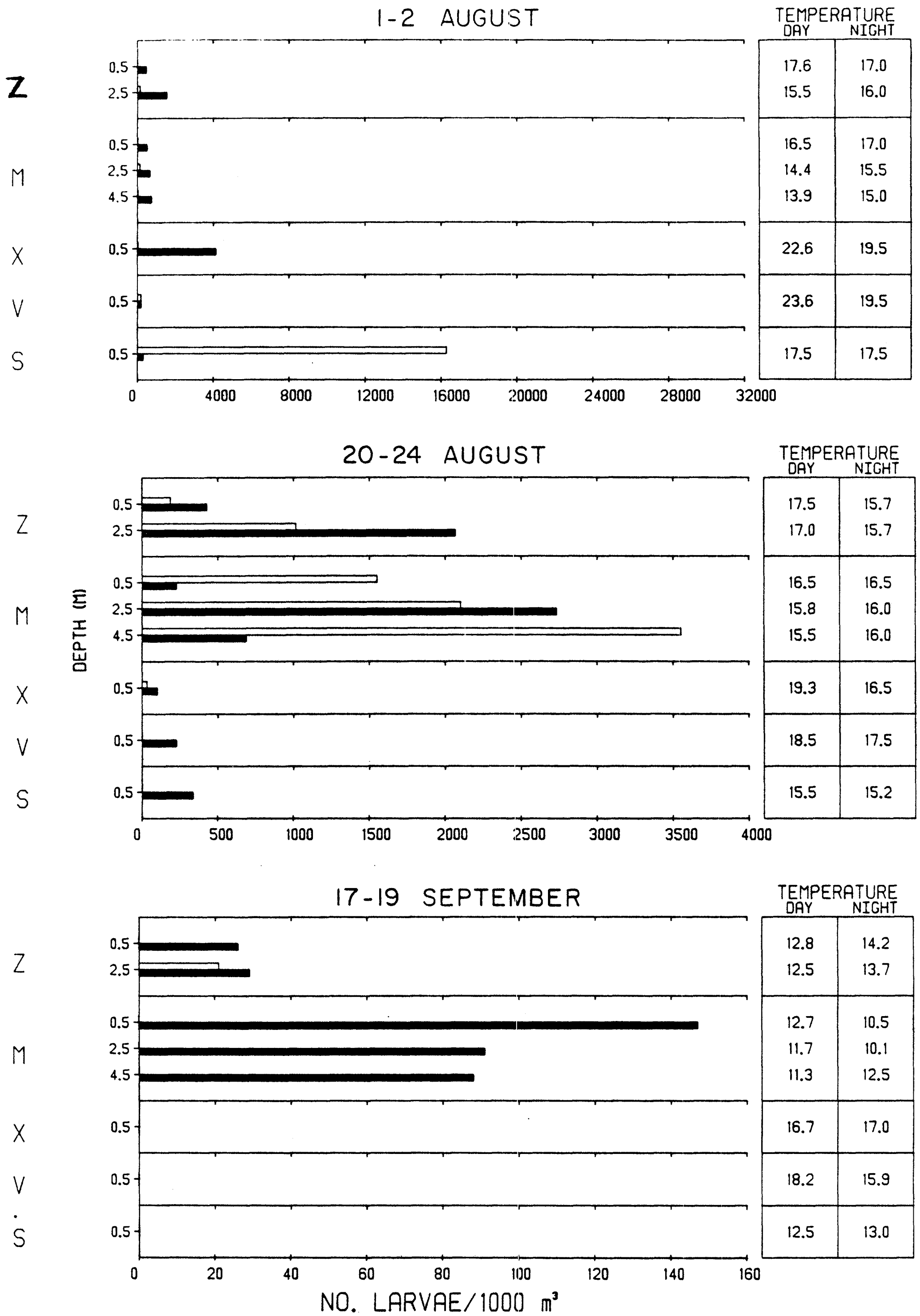


Fig. 66 . Continued.

construction activity) in shoreline areas of Pigeon Lake may also have forced alewives from the beach zone causing increased alewife spawning at greater depths in Pigeon Lake.

The low densities of alewife larvae observed in early June near the Campbell Plant in 1979 compared with 1977-1978 showed the yearly variability in times of first major alewife occurrences. During early June (1-3) 1977 when Lake Michigan water temperatures were mostly less than 12 C, low occurrences of alewife larvae were reported similar to early June (4-7) 1979 when water temperatures were also mostly less than 12 C. Early June (5-7) 1978 sampling, however, indicated that water temperatures were mostly greater than 16 C and alewife larvae were abundant. Thus, it appears that temperature is the main factor determining the dates during which the first major alewife spawning occurs. It is interesting to note that during early June 1977 and 1979, when larval alewife were rare in Lake Michigan, highest densities were observed at beach stations near the onshore discharge, further implicating the discharge canal as their source.

With increased water temperatures recorded at Lake Michigan stations in late (18-20) June 1979 compared with early June, larval alewife began to occur sporadically in low (mostly less than 100 larvae/1000 m^3) densities at depths of 1.5 to 15 m (Fig. 67). Highest densities were observed at beach station R (south discharge) and P (south reference) (Fig. 67). The magnitude of difference between the south reference beach station (maximum less than 499 alewife larvae/1000 m^3) may be due to recruitment of larvae from the discharge area. Length-frequency data indicated that all larvae caught at Lake Michigan stations in late June 1979 were newly hatched (Fig. 64).

Larval collections in Pigeon Lake during late June showed marked increases in larval alewife densities there compared with early June (Fig. 66). Although water temperatures were not markedly different between these month periods, larval alewives were present at open water stations as well as beach station S (influenced by Lake Michigan).

A comparison of 1979 larval alewife data with 1977-1978 data collected in Lake Michigan shows no drastic differences. During late June of 1977-1979 in Lake Michigan near the Campbell Plant, the warming trend appeared very similar (Fig. 68). This probably allowed for similar spawning and hatching trends among years. In Pigeon Lake early June sampling (1977-1979) typically collected larval alewives primarily at station M (6 m, influenced by Lake Michigan) and Z (intake canal) (Fig. 66). Due to the transient nature of the water at these stations, larvae observed were probably transported from Lake Michigan. Occasional occurrences of larvae at beach stations in Pigeon Lake as well as observation from 1977 to 1979 document alewife spawning in Pigeon Lake. Indeed, during 1977 an early June spawning peak in Pigeon Lake occurred at a time when there was little indication of alewife spawning in Lake Michigan. Spawning in June 1978-1979 however, was less intense, possibly due to the disruption of the area by construction-related activities.

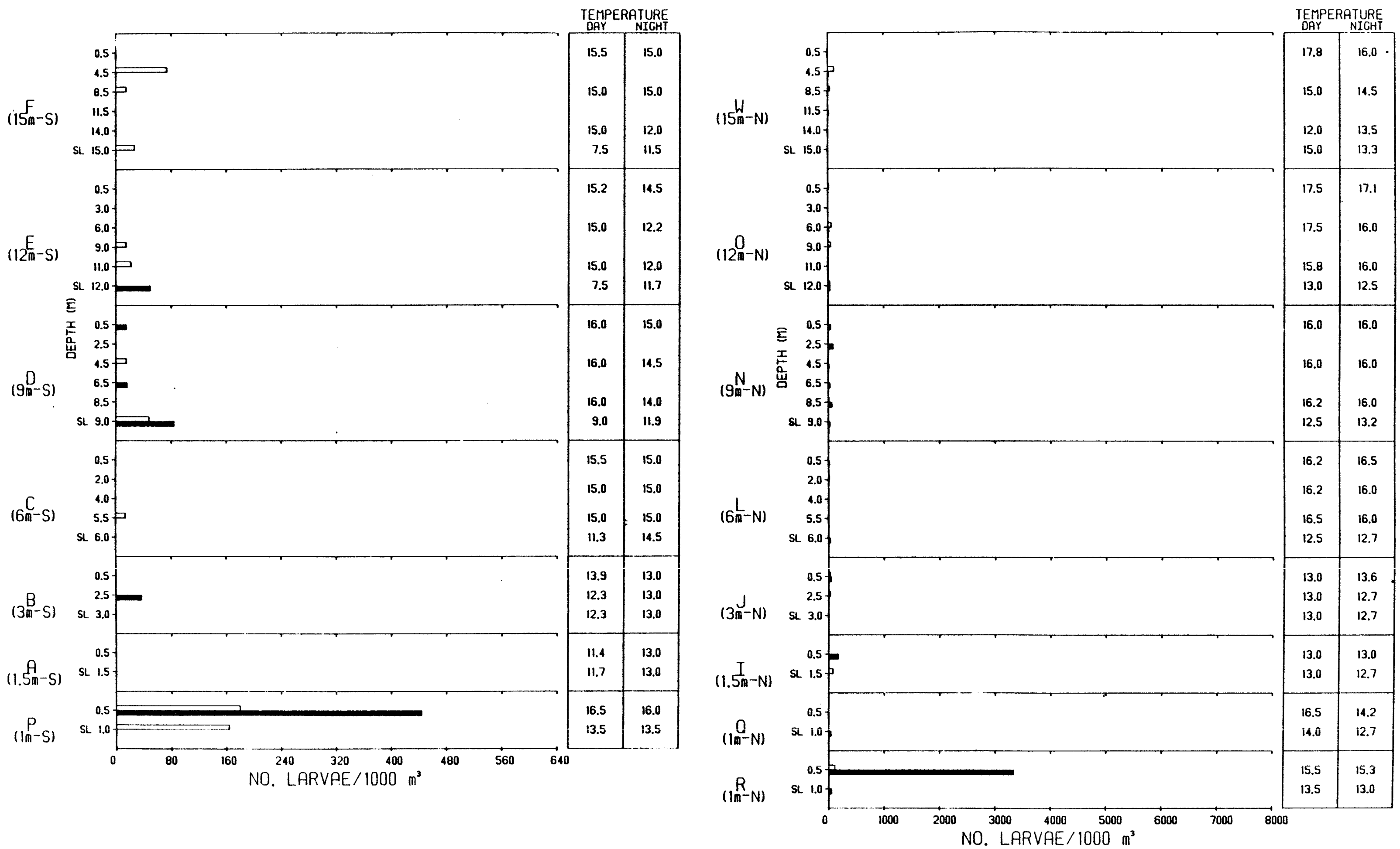


Fig. 67. Density of larval alewives (no./1000 m^3) at Lake Michigan stations near the J.H. Campbell Plant, eastern Lake Michigan, 18-20 June 1979. □ = day, ■ = night, SL = sled, ND = no data.

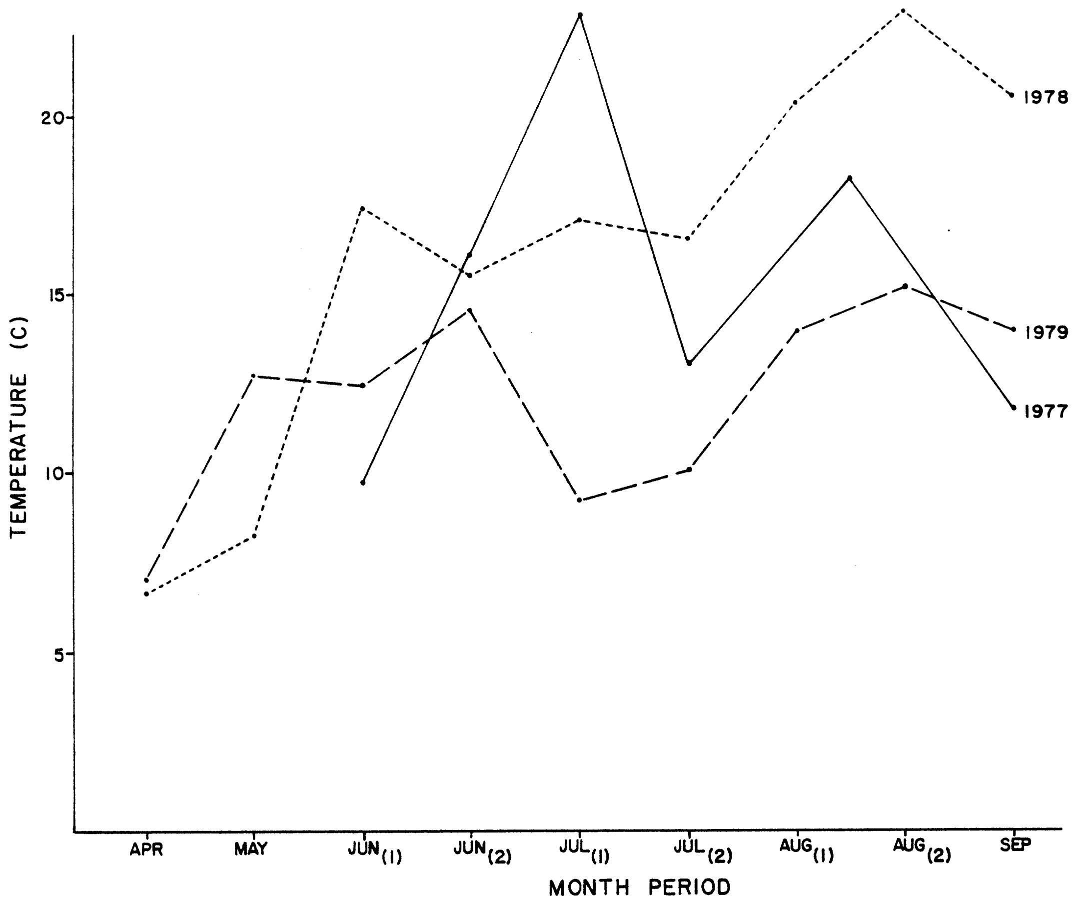


Fig. 68. Mean water temperature at selected larval fish sampling stations (P,A,B, C,Q,R,I,J,L) in Lake Michigan pooled over depths 1-6 m near the J.H. Campbell Plant, eastern Lake Michigan 1977-1979.

July--As during 1977-1978, the first indication in Lake Michigan near the Campbell Plant of a major hatching peak in 1979 occurred in early July (Fig. 64). In contrast to earlier years, however, the hatching peak in July 1979 was considerably less intense. Densities of larval alewives exceeding 1000 larvae/1000 m^3 were common at depths of 1-15 m during early July 1977-1978; however, this high density was only observed at the two beach stations near the discharge during 1979. The majority of larval alewife densities during early July 1979 did not exceed 500 larvae/1000 m^3. The reason for the comparatively less intense hatching peak in early July 1979 compared with early July 1977 and 1978 is probably related to temperature. During 1977 and 1978, the warming of Lake Michigan near the Campbell Plant had continued through our early July sampling trips (Fig. 68). During 1979, however, a deflection in the warming trend, caused by upwelling of cold water,

was observed. Decreased temperatures during early July 1979 probably caused a cessation of alewife spawning/hatching activity in all but warmer nearshore water. Alewife larvae in early July 1979 were primarily distributed at depths of 6 m or less (Fig. 69). Length-frequency data (Fig. 64) indicated that most larvae caught in Lake Michigan in early July were newly hatched, with a small complement of larger (greater than 7 mm) larvae also present.

Sampling in Pigeon Lake at stations M (6 m, influenced by Lake Michigan) and Z (intake canal) during early July 1979 also showed lower densities of larvae compared with early July 1977 and 1978 (Fig. 66). These lower densities of larval alewives were probably the result of lower Lake Michigan densities since much of the water sampled at these stations flows in from Lake Michigan. Absence of larvae from beach stations in Pigeon Lake in early July 1979 indicates that, despite temperatures conducive to alewife spawning/hatching, very little if any reproductive activity occurred there at this time.

During late July (17-19) 1979 water temperatures did not indicate that there was any substantial warming since the previous early July field trip. With most water temperatures less than 10 C, again intense alewife spawning was seemingly inhibited as the majority of larval densities observed at Lake Michigan stations were less than 500 larvae/1000 m^3 (Fig. 70). As during early July, distribution of larvae found in late July at Lake Michigan stations was primarily at depths of 6 m or less. Length-frequency data (Fig. 64) indicated that most larvae caught were newly hatched.

In comparison with late July 1977 and 1978, larval alewife abundance was notably lower in July 1979. During late July 1978 and 1979, larvae were generally distributed at depths to 15 m with increased abundance at beach stations. Again, the decrease in larval alewife populations in late July 1979 compared with late July 1977 and 1978 seems related to temperature.

In Pigeon Lake during late July, larval alewife abundance showed a marked increase over early July levels. Occurrence of over 2000 larvae/1000 m^3 at beach station S (influenced by Lake Michigan) gives an indication that spawning had occurred in Pigeon Lake to a greater extent than indicated from earlier sampling. Length-frequency data (Fig. 64) indicated over 70% of the larvae caught at beach stations in Pigeon Lake were newly hatched. High densities of larvae at station M (6 m, influenced by Lake Michigan) and station Z (intake canal) may be due to increased spawning/hatching activity in Pigeon Lake.

Length-frequency data from early and late July Lake Michigan samples raise an important question as to the fate of larval alewives spawned during times of upwellings. It would be expected that if those larvae spawned at Lake Michigan stations in early July had survived, that they would make up part of the complement of those larvae caught in late July. Our previous study during July 1977 and 1978 indicates that with a warming trend following an early July hatching peak, larger larvae are readily caught in late July. This was not the case in 1979 when colder upwelled water remained inshore throughout July. Our data therefore suggest that larvae spawned either during

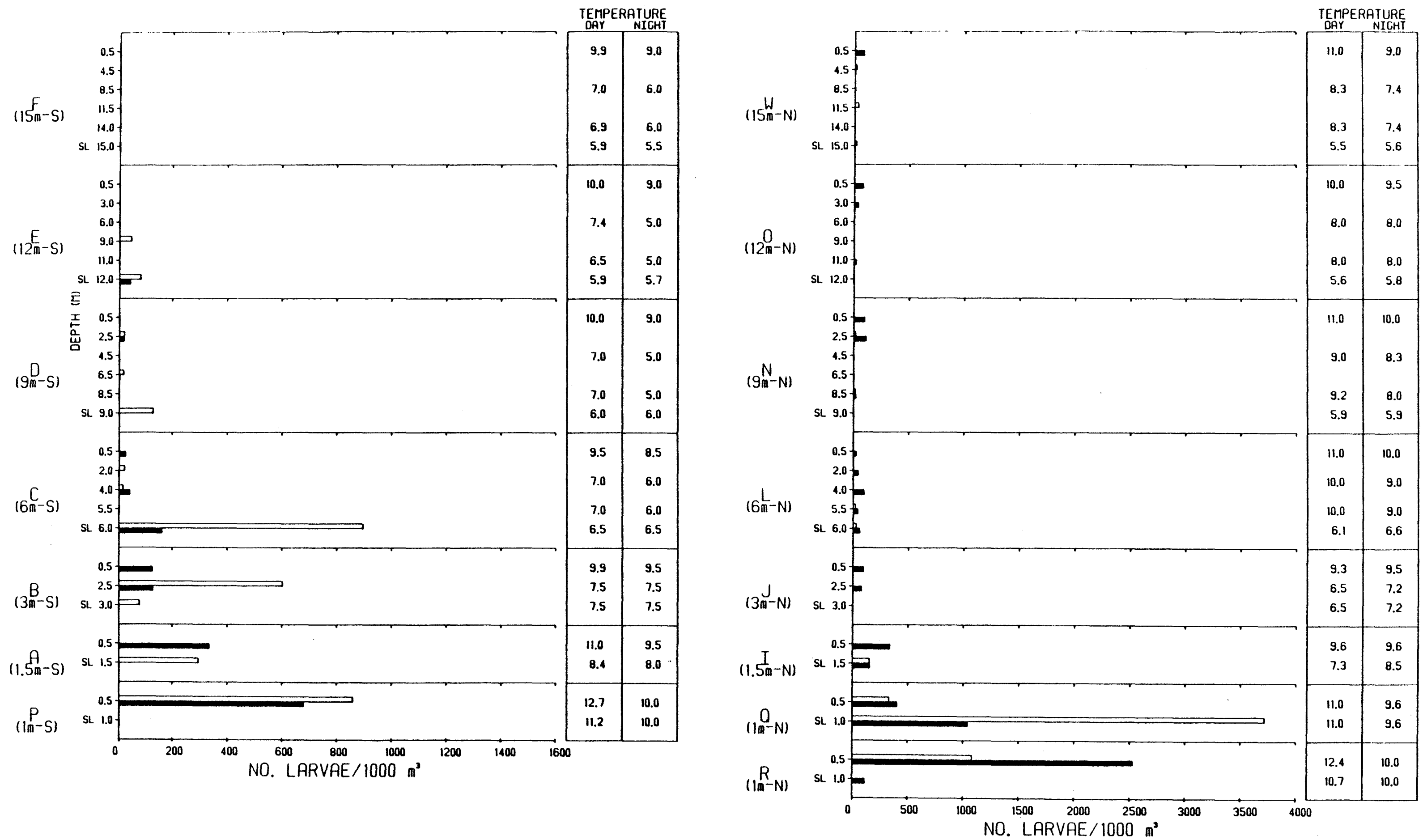


Fig. 69. Density of larval alewives (no./1000 m^3) at Lake Michigan stations near the J. H. Campbell Plant, eastern Lake Michigan, 2-4 July 1979. ☐ = day, ■ = night, SL = sled, ND = no data.

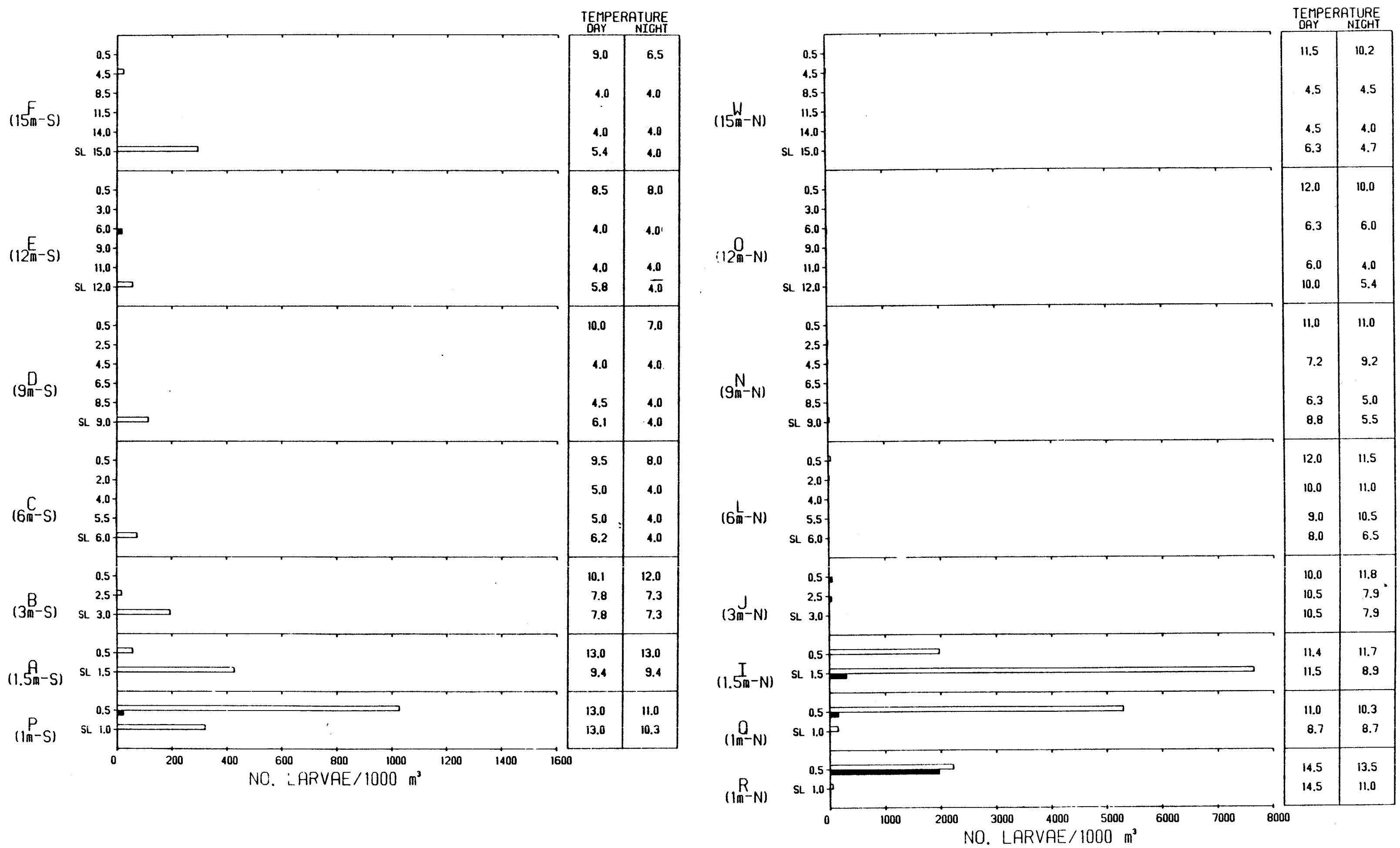


Fig. 70. Density of larval alewives (no./1000 m^3) at Lake Michigan stations near the J.H. Campbell Plant, eastern Lake Michigan, 17-19 July 1979. □ = day, ■ = night, SL = sled, ND = no data.

or just previous to an upwelling of colder water (less than 12 C) may experience decreased survival. Edsall (1970) indicated that development of a functional jaw in alewife does not occur at water temperatures below about 10 C, and thus would negatively affect survival. Thus, the implications of upwellings are numerous and suggest that the extent and timing of upwellings could have considerable impact on a year class of alewives.

August--With resumption of a warming trend in Lake Michigan in early August, larval alewife densities at depths to 15 m indicated increased spawning/hatching activity. Larvae in early August at Lake Michigan stations were generally distributed at depths of 3-15 m, showing increased densities at the beach and 1.5-m stations (Fig. 71). At deeper (3-15 m) stations, surface strata tended to exhibit higher larval alewife densities. Examination of length-frequency data (Fig. 64) indicated that the majority of larvae caught in early August at Lake Michigan stations were newly hatched. There was, however, a group of larger (greater than 10 mm) larvae present which were probably the result of late July spawning activity.

A comparison of early (1-4) August 1978 Lake Michigan larval alewife data with 1979 data shows marked similarities in distributional patterns. In comparing abundances, however, early August 1979 samples showed notably lower densities of alewife larvae which may be due to natural variability. However, it may also be caused by reduced numbers of larvae hatched in Lake Michigan during July 1979 compared with July 1978, which would cause reduced levels during August sampling.

Early August sampling in Pigeon Lake showed a high density of larvae at beach station S (influenced by Lake Michigan) as well as increased densities at station X (undisturbed Pigeon Lake) compared with late July (Fig 66). Length-frequency data (Fig. 64) showed that less than 5% of the larvae caught in Pigeon Lake during early August were newly hatched with a mean length of 12.8 mm (SE = 0.3). This was in sharp contrast with concurrent Lake Michigan data and indicates little spawning/hatching activity in Pigeon Lake in early August.

With continued higher water temperatures in late August, densities of larval alewives at Lake Michigan stations remained at high levels (Fig. 72). In late August, as in early August, highest densities of alewife larvae were reported at shallower (1.5 m and less) depths; however, alewives were also abundant (more so than early August) at depths to 15 m (Fig. 72). Although water temperatures were comparable between periods, it appeared that higher densities of larval alewives were present at stations 3 m and less at the south transect during late August than were found at north transect stations. Length-frequency data of larval alewives caught at Lake Michigan stations in late August showed that a wide size range of larval alewives was present (Fig. 64). Indications were that at this time, recently hatched larvae as well as those larvae hatched in late July and early August were collected during late August in Lake Michigan. A very similar length-frequency distribution was indicated from Pigeon Lake collections in late August (Fig. 64) when larval alewives were primarily caught at stations M (6 m, influenced by Lake Michigan) and Z (intake canal).

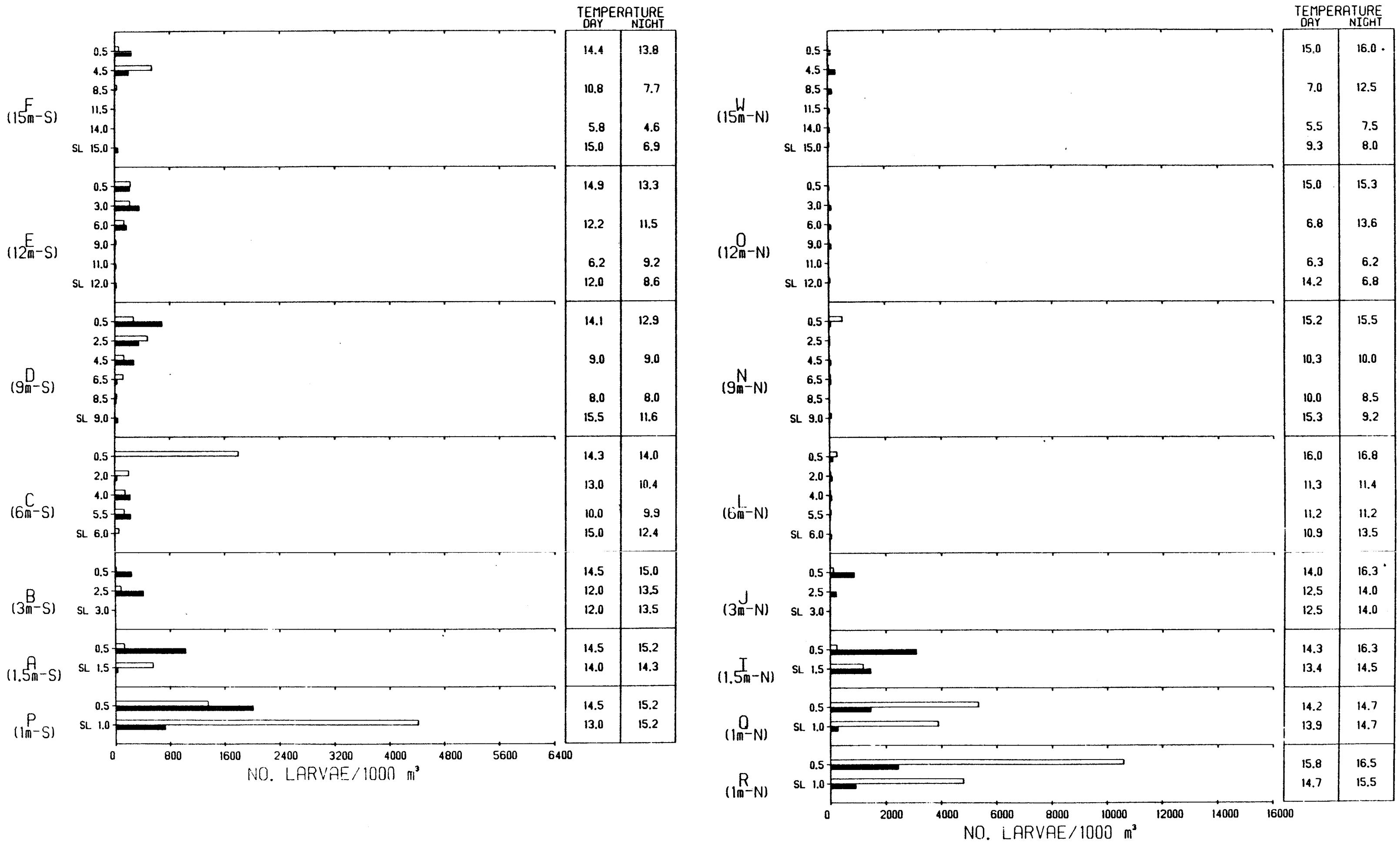


Fig. 71. Density of larval alewives (no./1000 m^3) at Lake Michigan stations near the J.H. Campbell Plant, eastern Lake Michigan, 1-2 August 1979. ☐ = day, ■ = night, SL = sled, ND = no data.

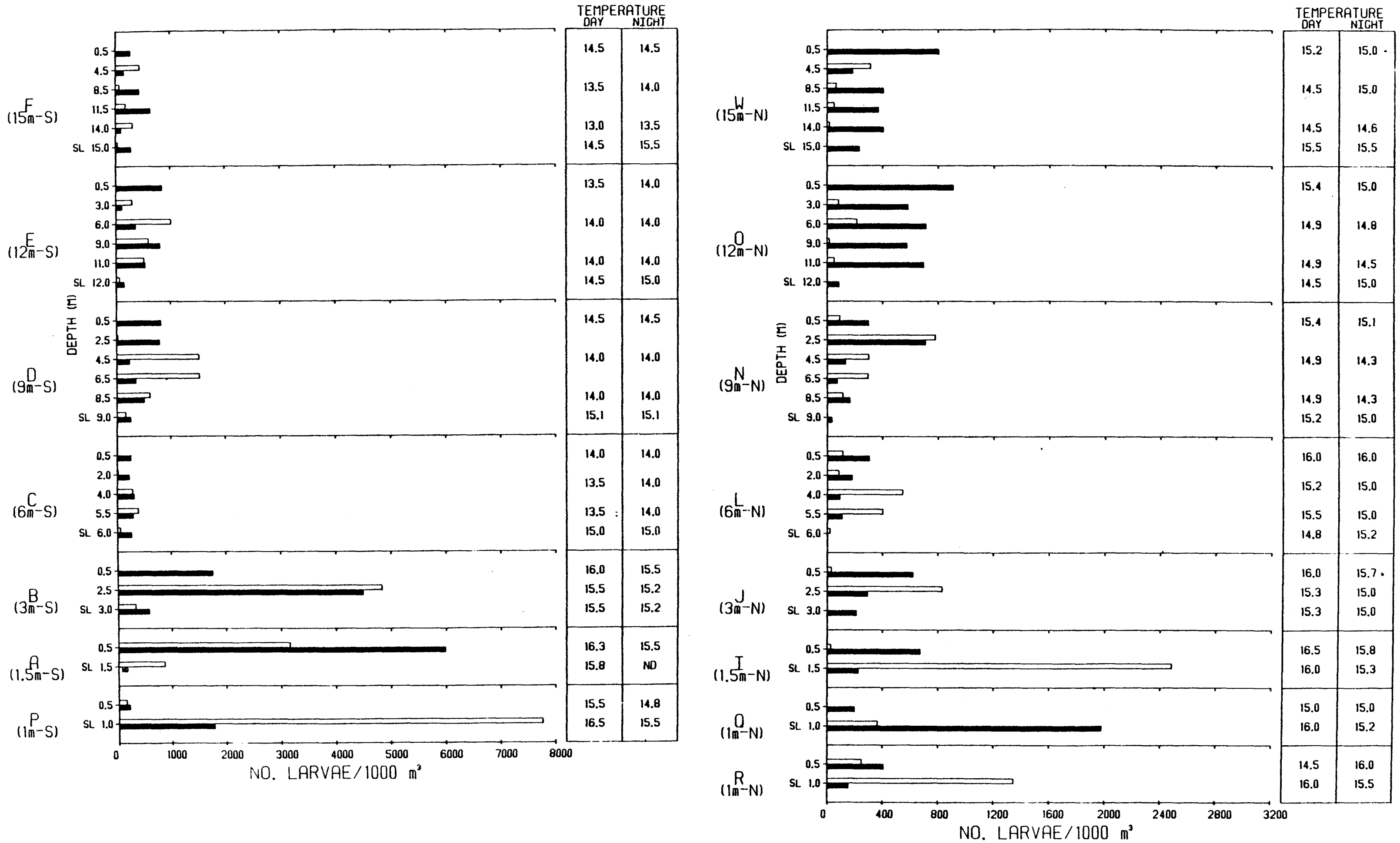


Fig. 72. Density of larval alewives (no./1000 m^3) at Lake Michigan stations near the J.H. Campbell Plant, eastern Lake Michigan, 20-24 August 1979. □ = day, ■ = night, SL = sled, ND = no data.

In general, it appears that the hatching peak of alewives in the vicinity of the Campbell Plant during 1979 occurred in August. In reviewing previous years' data, it seems probable that the major spawning peak for alewives more typically occurs in late June or July. Upwelled cooler water occupying the inshore (15 m and less) area during July 1979 inhibited major spawning activity during that month. Subsequent warming of inshore water in early August reinitiated spawning and caused increased larval abundances in August 1979 compared with July.

September--Larval alewives were still abundant in Lake Michigan near the Campbell Plant in September (Fig. 73). Distribution of alewife larvae at this time was similar to that observed in August, showing higher densities at depths of 6 m and less. Densities of alewife larvae at deeper (9-15 m) stations in September were generally less than 200 larvae/1000 m^3. Densities of alewife larvae during September 1979 when contrasted with similar data in 1977 and 1978 indicated that substantially more alewife larvae were present in September 1979. Length-frequency data from September 1979 (Fig. 64) indicated that many of those larvae present were smaller ($\bar{x}$ = 13.9 mm, SE = 0.3) than those caught in September 1977 ($\bar{x}$ = 21.1 mm, SE = 0.2) and 1978 ($\bar{x}$ = 19.2 mm, SE = 1.2). Yearly differences in abundance during September are thus explained since spawning occurred at a later date in 1979 (as indicated by presence of smaller larvae), compared with 1977 and 1978 when most larvae had already grown beyond maximum larval length (25.4 mm) due to earlier spawning.

Pigeon Lake stations during September exhibited decreased larval abundances compared with August. No larvae less than 12 mm were caught there (Fig. 64) suggesting that spawning in Pigeon Lake had ceased prior to the Lake Michigan cessation.

Entrainment--

The total yearly estimated larval alewives entrained at the Campbell Plant exhibited a significant decline during 1979 (estimated 23.4 million entrained) compared with 1978 (estimated 48.9 million entrained). Although the reasons for this are unclear, field collections, as well as entrainment samples, give initial indication that alewife spawning in the area of the Campbell Plant in 1979 was not as successful as during 1978. Reasons for this may be related to temperature. A prolonged period of upwelling during July may have impeded spawning, as well as decreased the survival of those eggs and larvae spawned during this month. The July 1979 upwelling may have affected the survival of larvae spawned in June.

Larval alewives first occurred in entrainment samples during 16-17 May. The low densities (less than 5 larvae/1000 m^3) observed at this time indicated spawning in Pigeon Lake as well as Lake Michigan prior to this time had not been extensive. Low densities (less than 30 larvae/1000 m^3) of alewives continued throughout June (Fig. 74), resulting in a relatively low entrainment loss of this species (estimated less than 10,000 alewife larvae entrained in a 24-h period) (Fig. 75) during June. Length-frequency data from larvae entrained in June (Fig. 64) compared closely with field-caught specimens and indicated that the majority were newly hatched (5 mm or less).

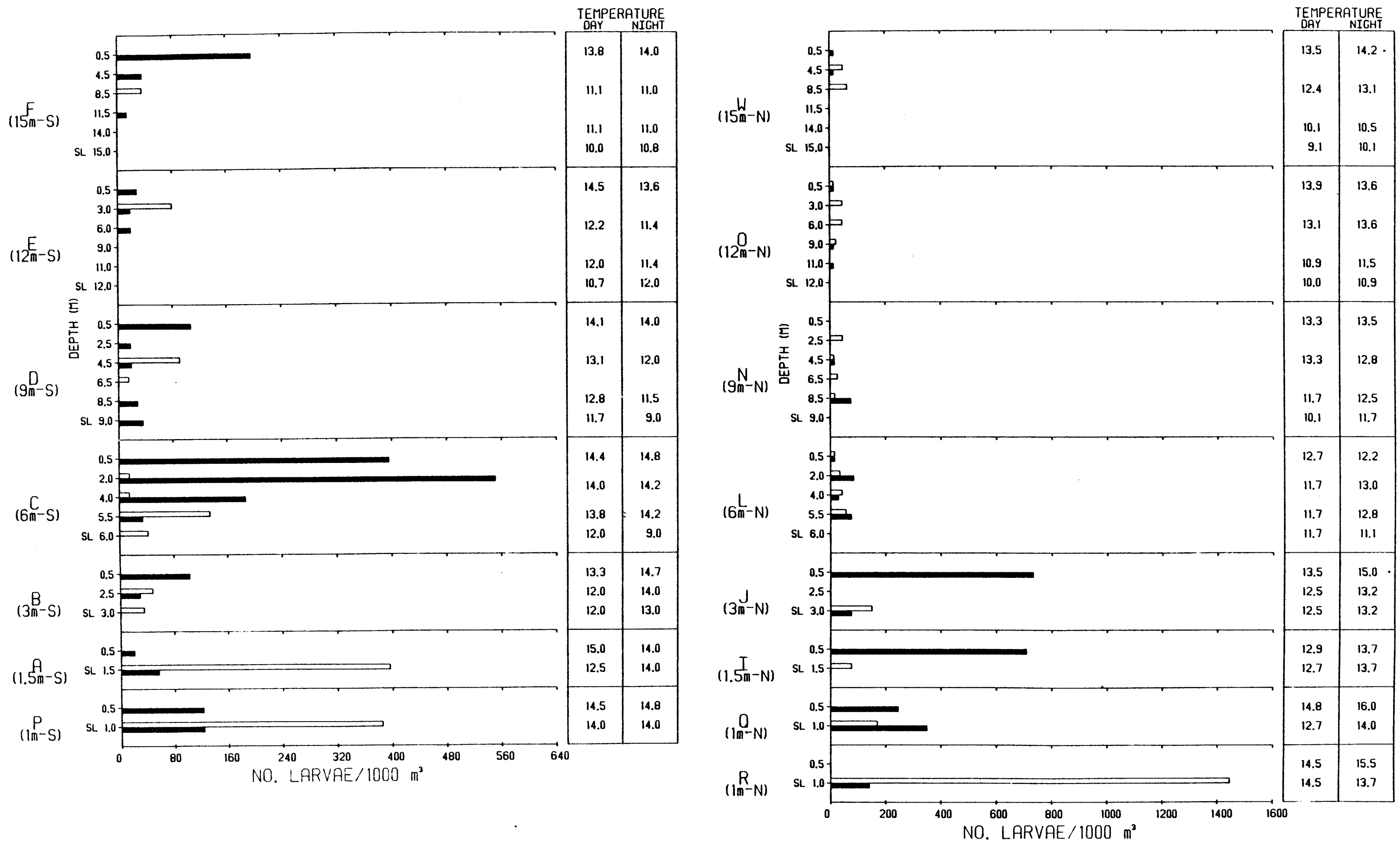


Fig. 73 . Density of larval alewives (no./1000 m^3) at Lake Michigan stations near the J.H. Campbell Plant, eastern Lake Michigan, 17-19 September 1979. □ = day, ■ = night, SL = sled, ND = no data.

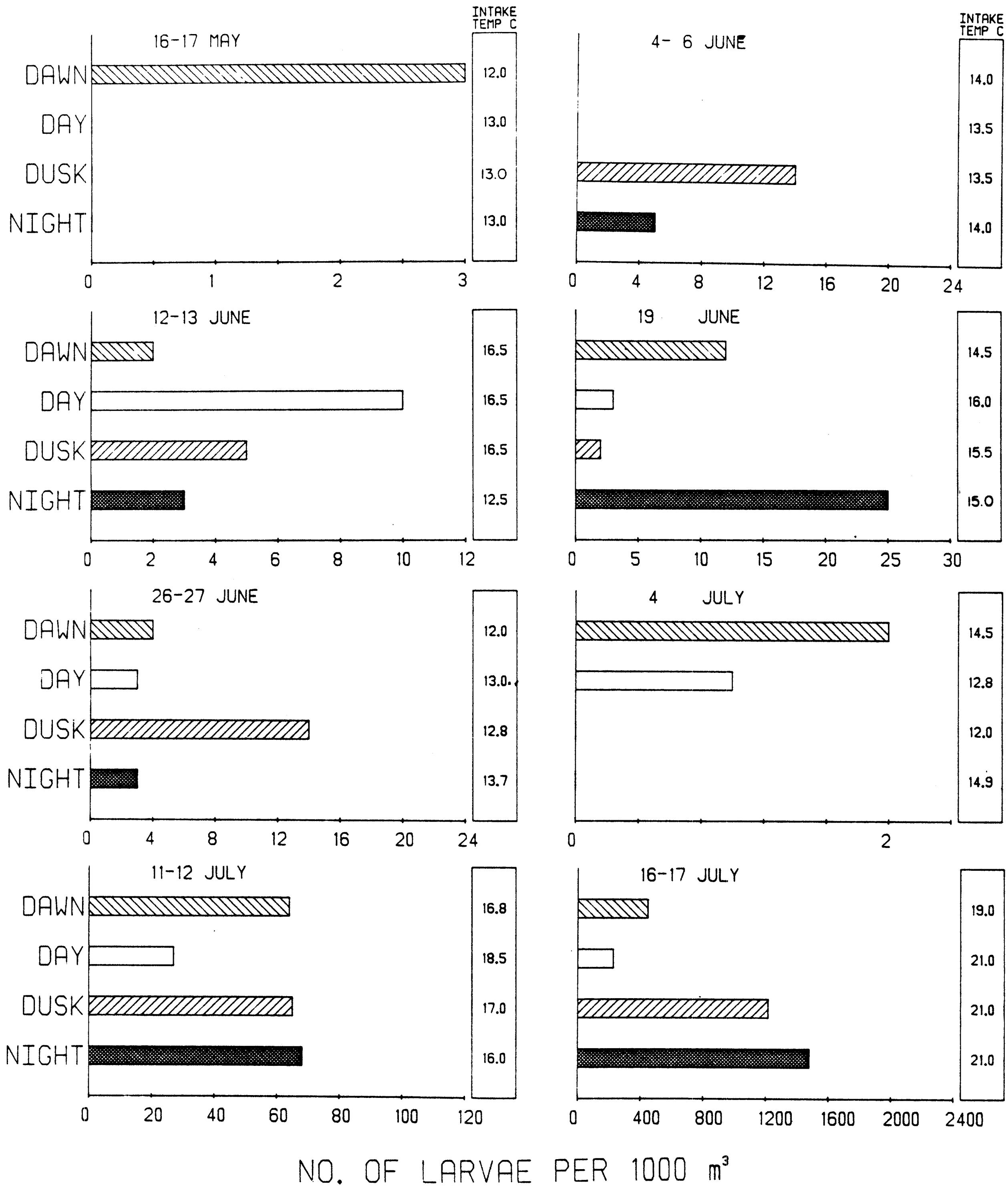
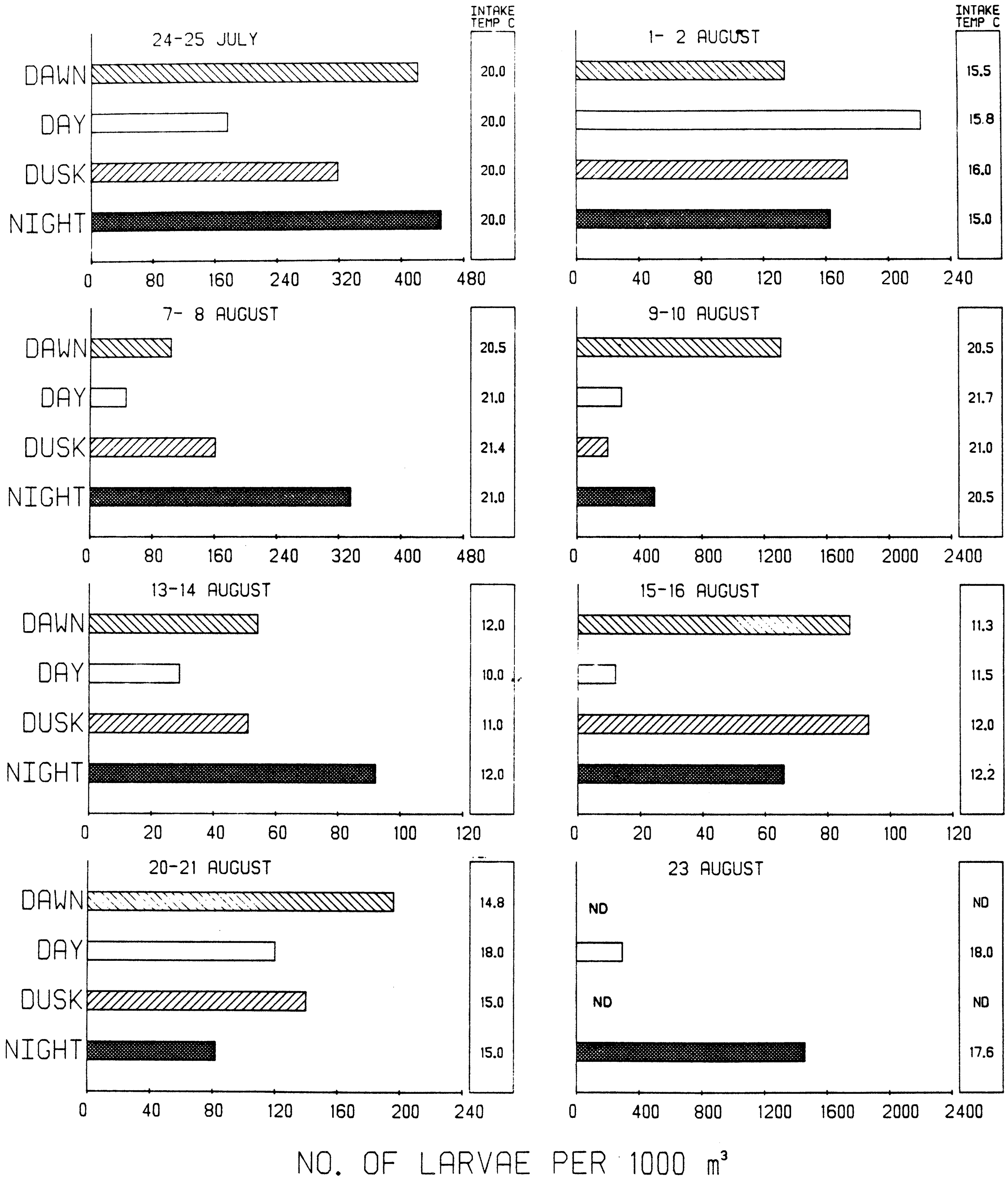


Fig. 74. Density of alewife larvae (no./1000 m^3) in weekly dawn, day, dusk and night entrainment samples at the J.H. Campbell Plant, eastern Lake Michigan, 1979. ND = no data.



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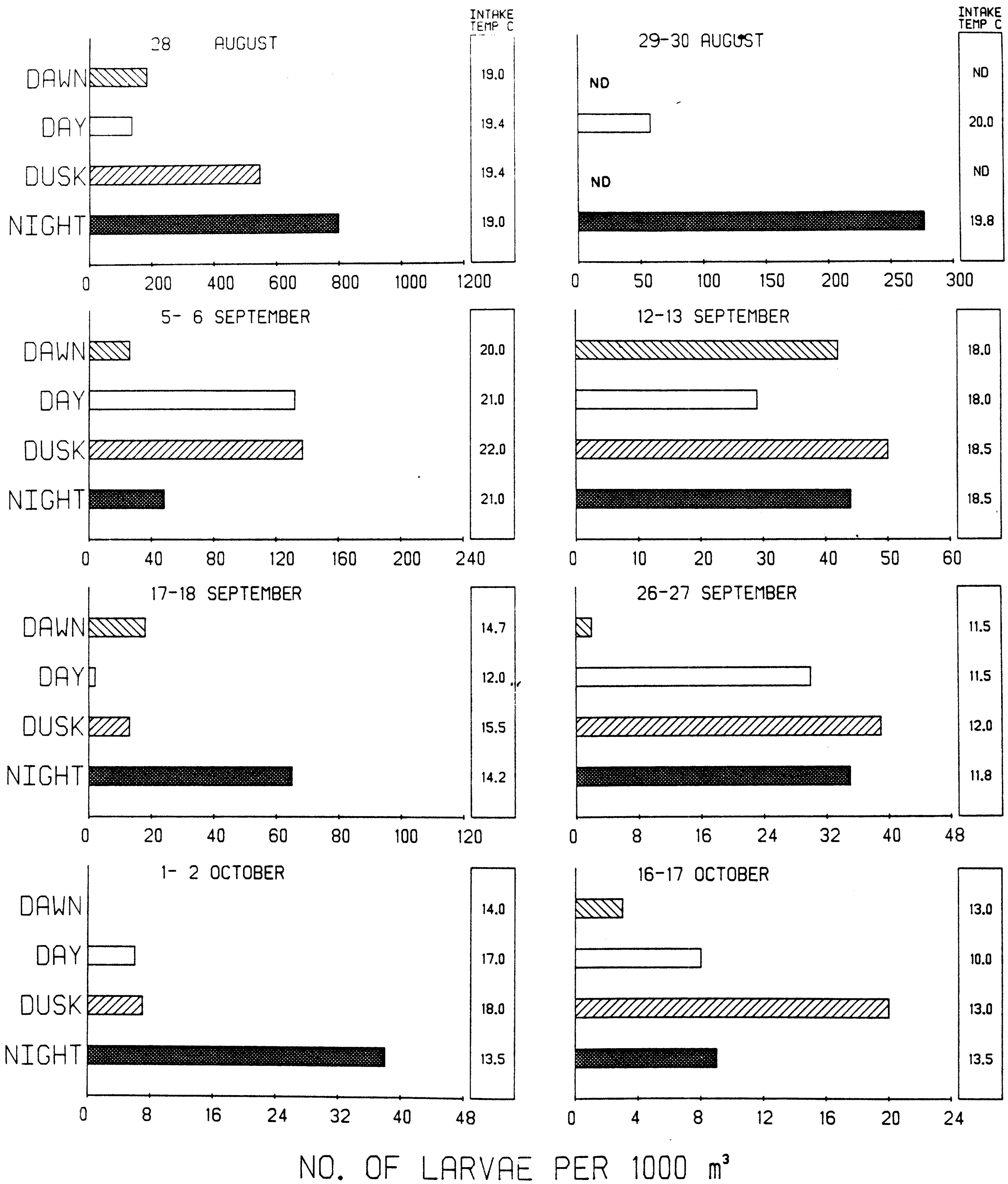

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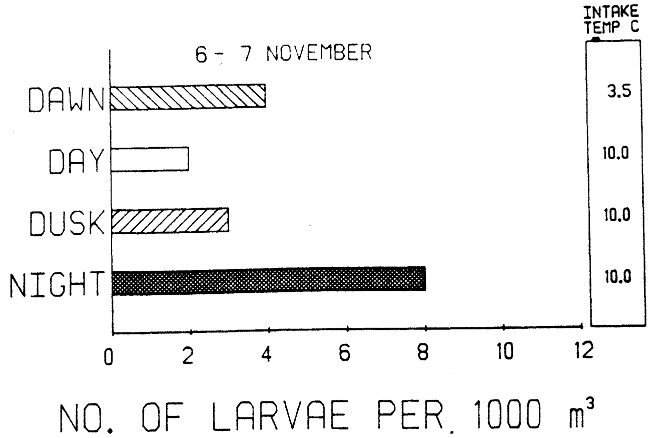
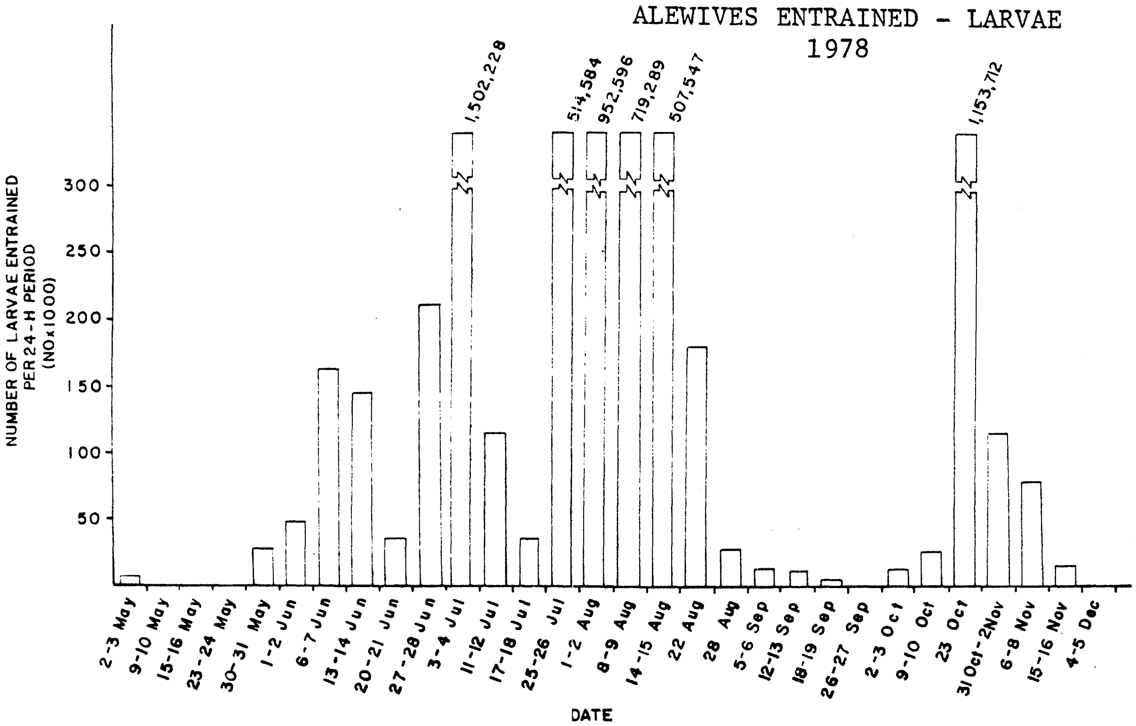


Fig. 74. Continued.

July marked the first substantial loss of alewife larvae due to entrainment at the Campbell Plant in 1979. After the initially low densities of alewives in entrained water during the earliest July (3-4) period, densities showed a marked increase during 11-12 July (Fig 74). Further increase in densities of alewife larvae in entrained water during 16-17 July resulted in the maximum number entrained in a 24-h period (over 1 million) for the entire year (Fig. 75). Length-frequency data indicated that, similar to earlier July dates, the vast majority of those larvae entrained on this date (16-17 July) were newly hatched. An increasing proportion of previously hatched larvae (greater than 5 mm) relative to recently hatched larvae (5 mm and less) was found during 24-25 July (Fig. 64) suggesting, along with decreased densities in entrained water, that less alewife spawning/hatching activity was occurring during later (24-25) July compared with mid (16-17) July. Origin of those larvae entrained in July is not known. However, increased hatching activity in Pigeon Lake during July, as well as very high densities of larvae at north transect stations in Lake Michigan in July, implicate both water bodies as contributing to peak entrainment losses.

Densities of larval alewives in entrainment samples during early August (1-2 and 7-8) sampling dates were lower than in late July (24-25); however, alewives in most diel periods exhibited densities of over 100 larvae/1000 m^3 (Fig. 74) resulting in a substantial (over 250,000) loss in a 24-h period. Length-frequency data from both dates (August 1-2 and 7-8) showed a wide range of sizes present, with continued hatching activity indicated by the presence of larvae smaller than 5 mm (Fig. 64). A combination of density (Fig. 74) and length-frequency data (Fig. 64) suggest a slight hatching peak for alewives during 9-10 August sampling. Entrainment loss at this time exceeded 705,000 larvae in a 24-h period; over 50% of these larvae were 5 mm or less indicating they were recently hatched. The first substantial entrainment loss of alewife fry was also observed on 9-10 August (Fig. 76) when over 120,000 fry/24-h period were entrained. It is difficult to determine the reason for such high



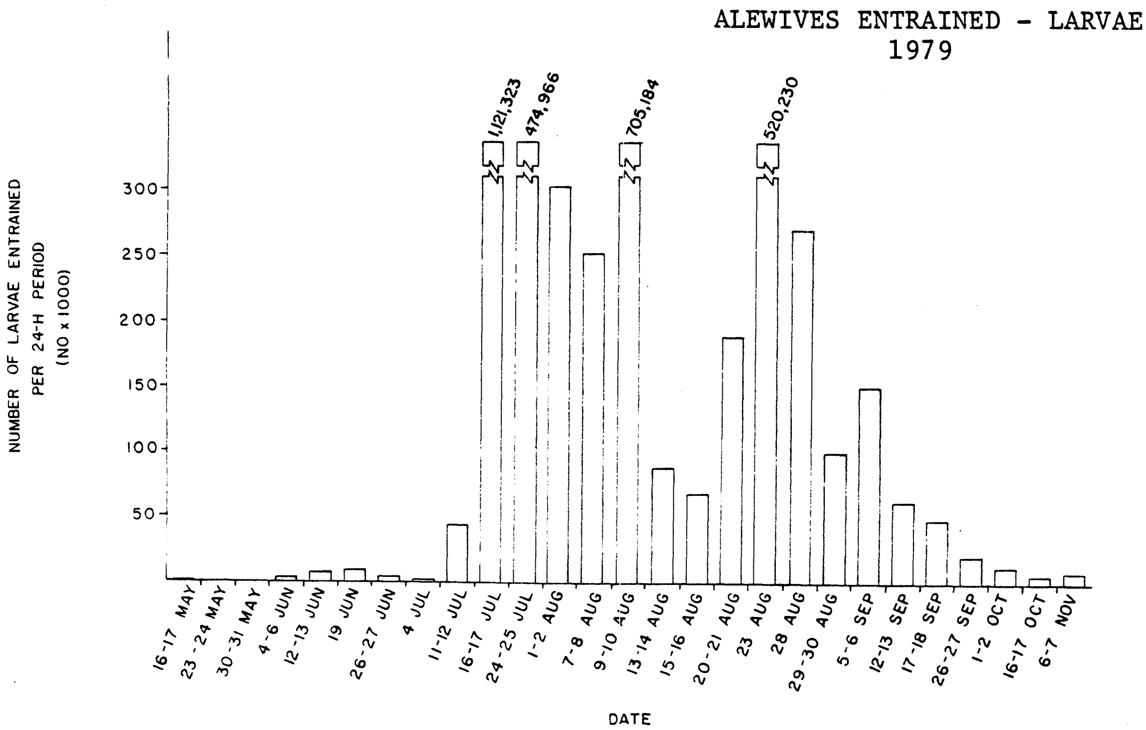


Fig. 75. Total number of alewife larvae entrained during a 24-h period projected from densities observed in the 16 samples collected weekly at the J.H. Campbell Plant, eastern Lake Michigan, 1978-1979.

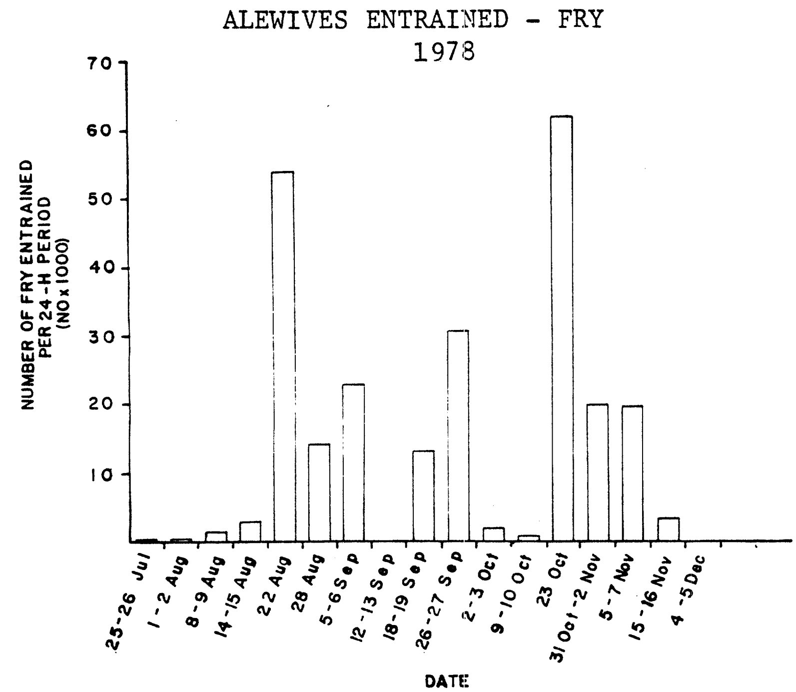
entrainment of this size of alewife. Our observations indicate they can easily avoid intake currents. It is therefore concluded that they moved into the intake area in response to environmental factors which we do not understand.

Decreased water temperatures during the 13-14 and 15-16 August sampling dates were undoubtedly responsible for the dramatic decreases in alewife larvae densities at these times (Fig. 74) compared with 9-10 August. Length-frequency data showed a decreased proportion of newly hatched larvae suggesting cooler temperatures had suppressed alewife spawning/hatching activity in mid-August (Fig. 64). It is apparent that cooler water temperatures in August had little diminishing effect on fry entrainment as a peak number of alewife fry were entrained on 13-14 August (Fig. 76). With resumption of warmer (greater than 15 C) water temperatures, during later (20-21, 23, 28 and 29-30) August sampling dates, larval densities in entrained water showed increasing values (Fig. 74), resulting in losses of 100,000 to over 500,000 larvae in a 24-h period from 20-30 August (Fig. 76). Entrainment of alewife fry over these dates (20-30 August) fluctuated without conspicuous trend between 7,000 and 66,000 larvae/24-h period. Later sampling dates in August exhibited a trend toward decreased numbers of newly hatched larvae (Fig. 64) showing the decline in recent hatching rates which would be expected near the end of the spawning season.

In contrast with September 1977-1978 data indicating diminished entrainment of alewife larvae and fry, entrainment of these stages during September 1979 remained relatively high. Densities of larval alewives ranging from 2 to 277 larvae/1000 m^3 (Fig. 74) resulted in entrainment losses of nearly 150,000 in a 24-h period on 5-6 September which showed a gradual decrease to nearly 20,000/24-h period on 26 September (Fig. 75). Entrainment loss of fry showed a similar declining trend from over 217,000/24-h period on 5-6 September to over 14,000/24-h period on 26 September.

A comparison of 1977-1978 length-frequency data with data collected in September 1979, suggests that the reason for comparatively higher entrainment loss in September 1979 may be due to the continuation of intensive alewife spawning to a later date in 1979. Throughout September sampling periods, larvae less than 10 mm comprised relatively high proportions of the larval alewife catch in both entrainment and field collections. This was not the case in September 1977-1978 when larvae less than 10 mm were rare in collections. Our data suggest, therefore, that higher entrainment of larval alewives in September 1979 compared with similar periods in 1977-1978 was caused by increased abundance in September 1979 of smaller larvae which are more susceptible to entrainment.

Entrainment of larval alewives during October showed the continued downward trend which began in September. Over 12,000 alewife larvae/24-h period were entrained on 1-2 October which declined to less than 6,000 larvae/24-h period on 16-17 October. Mean lengths of larvae entrained in October showed consistent increases compared with larval alewives entrained in September (Fig. 64). Fry entrainment during October showed a marked decrease compared with September values (Fig. 76) and may reflect the beginning of a



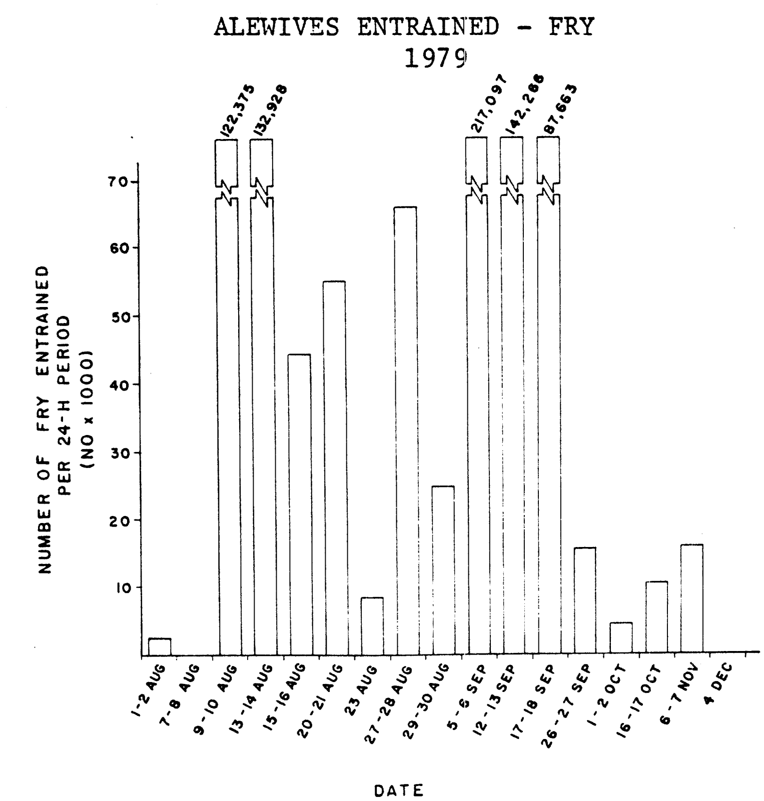


Fig. 76. Total number of alewife fry entrained during a 24-h period projected from densities observed in the 16 samples collected weekly at the J.H. Campbell Plant, eastern Lake Michigan, 1978-1979.

movement of YOY alewives offshore to deeper water in Lake Michigan. A single set of samples taken in November indicated low densities (less than 9,000 larvae/24-h period) coincident with a loss of 16,000 fry/24-h period. Since larvae entrained during November were large ($\bar{x}$ = 20.7 mm, SE = 0.7), factors causing their entrainment are unknown. Although it is known that larvae this size can avoid intake currents, data from 1977 to 1979 indicate that high densities of larger larvae and fry occasionally are present in entrained water from August to November. They may move into the area in response to food, light or current. In any event, their occasional occurrence exhibits no obvious trends. No larvae or fry were entrained during December 1979, concurring with their absence in field samples collected during December 1977 and 1978.

In 1979 there was a 53% decrease in the number of alewife larvae entrained compared to 1978, while in 1979 fry entrainment greatly increased. Fry entrainment represents a much more serious loss, since by the time fry reach lengths exceeding 25.4 mm, they have survived the period of highest mortality. A model which estimated production foregone by fish entrained and impinged in 1978 (Jude et al. 1979a) supports this contention. Production by fry exceeded that of larvae by approximately 1.7 times.

Summary--

In general, spawning activity in the vicinity of the Campbell Plant during 1979, as indicated by larval alewife densities, appeared less intense than during 1977-1978. Warming of inshore waters of Lake Michigan to temperatures conducive to alewife spawning occurred in late June 1979; however, an interruption of the normal warming trend of this area due to an extended upwelling of cold water impeded intensive alewife spawning. There was an indication that many larvae hatched at the beginning of the upwelling (early July) may not have survived to late July as indicated by length-frequency data.

The most intense spawning/hatching activity of alewives was during August as water temperature resumed an upward warming trend. This resulted in the occurrence of small, newly hatched larvae, which were collected later in the season than in previous years. The effect of later hatching on survival of those larvae is unknown.

Entrainment peaks for larval alewives were in July and August; however, overall estimated entrainment during 1979 (over 23 million, 33% of total) was less than half that of 1978 (over 48 million, 63% of total). Entrainment of smaller larvae continued into September, due to the later spawning peak of 1979. Sporadic occurrences of high densities of alewife larvae and fry in entrained water from September to November have been observed over 1977-1979.

Yellow Perch

Introduction--

During the 3 yr of preoperational study in the vicinity of the Campbell Plant, the source and distribution pattern of larval yellow perch has been difficult to explain. Jude et al. (1978) hypothesized that multiple-aged cohorts were present, one group resulting from a late April-early May spawning in Pigeon Lake, while another group of larval yellow perch occurred from a late May-early June spawning in Lake Michigan. Evidence to support such a theory was apparent from 1977 data even though sampling during May was not conducted. Length-frequency data from June revealed two distinct length groups of yellow perch larvae were present in entrainment samples and samples from Pigeon Lake (Jude et al. 1978). During June 1978, very few larvae were recovered from Lake Michigan samples (Jude et al. 1979a); however, in 1979, the size groups once again were apparent during June in Pigeon Lake as well as in entrainment samples.

Seasonal distribution--

Yellow perch were the second-most abundant species of larvae collected in 1979. Catch of yellow perch larvae has shown an overall increase during the 3 yr, particularly in Pigeon Lake. Sampling was not conducted in May 1977 and stations T and Y were excluded from the sampling regime after 1977. Comparing catches at the remaining stations (S, V, M and X) during June over 3 yr, revealed highest densities of yellow perch larvae at beach station S (influenced by Lake Michigan) at night in 1977 (179/1000 m^3). Very few larvae were caught in Pigeon Lake during June 1978, but 4584/1000 m^3 were observed at station V (undisturbed Pigeon Lake) in June 1979.

<u>April</u>--Although larval yellow perch were not obtained during April 1978, they were observed in entrainment samples the last week of April 1979 (Figs. 77 and 78). Densities at this time were low (less than 28/1000 m^3), but signaled the start of hatching in Pigeon Lake and/or the intake canal. These fish, averaging 5.7 mm (Fig. 77) were probably recently hatched. According to Scott and Crossman (1973), yellow perch eggs hatch in 8 to 10 days and newly hatched larvae are approximately 5.0 mm.

<u>May</u>--Larval yellow perch were recovered from all four Pigeon Lake stations, station Z (intake canal) and both transects in Lake Michigan. They were also captured during all 4 wk of entrainment sampling in May. Distribution patterns of yellow perch larvae in Pigeon Lake were similar during 1978 and 1979, however abundance was greater during 1979. During May yellow perch larvae, regardless of collection site, averaged 6.1 mm (Fig. 79). These fish again represent the first cohort, which resulted from spawnings in Pigeon Lake or the intake canal during mid- or late April. Those larvae collected in Lake Michigan during May were believed to have originated from these spawnings as well.

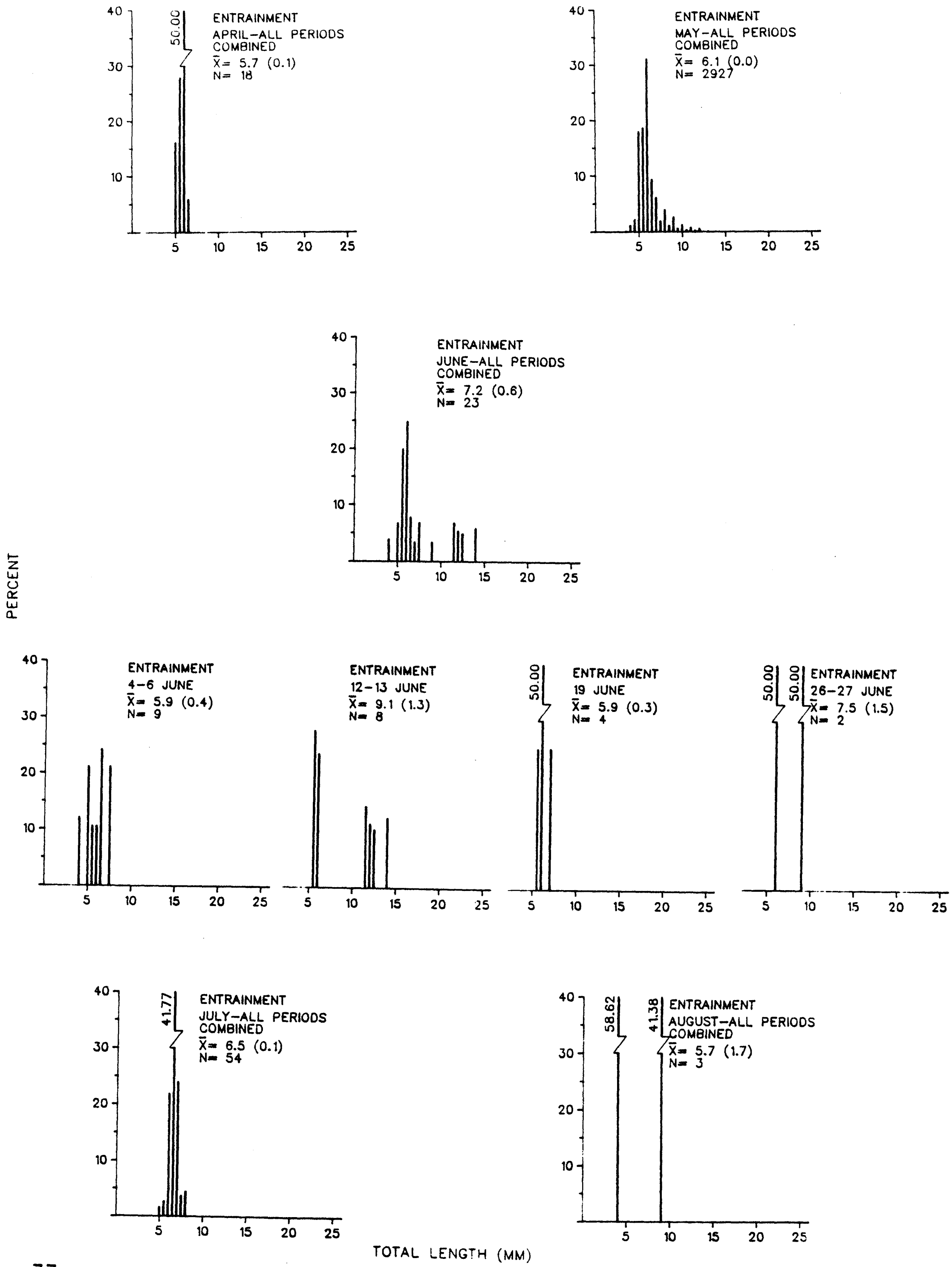


Fig. 77. Length-frequency histograms for larval yellow perch observed in entrainment samples collected during 1979 near the J. H. Campbell Plant, eastern Lake Michigan. $\overline{X}$ = mean, N = total number of larvae, standard error is given in parentheses.

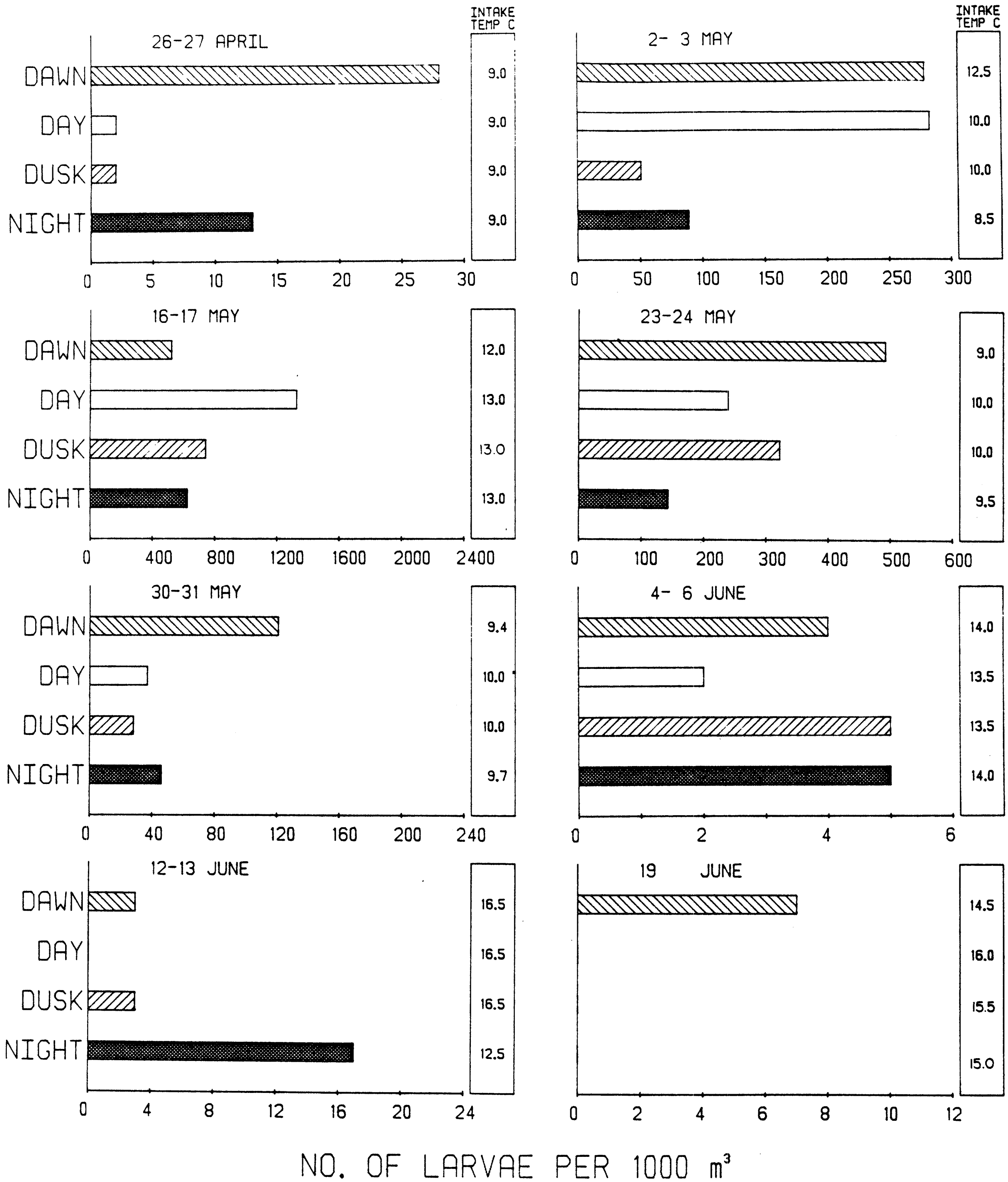


Fig. 78. Density of larval yellow perch (no./1000 m^3) in weekly dawn, day, dusk and night entrainment samples at the J. H. Campbell Plant, eastern Lake Michigan, 1979.

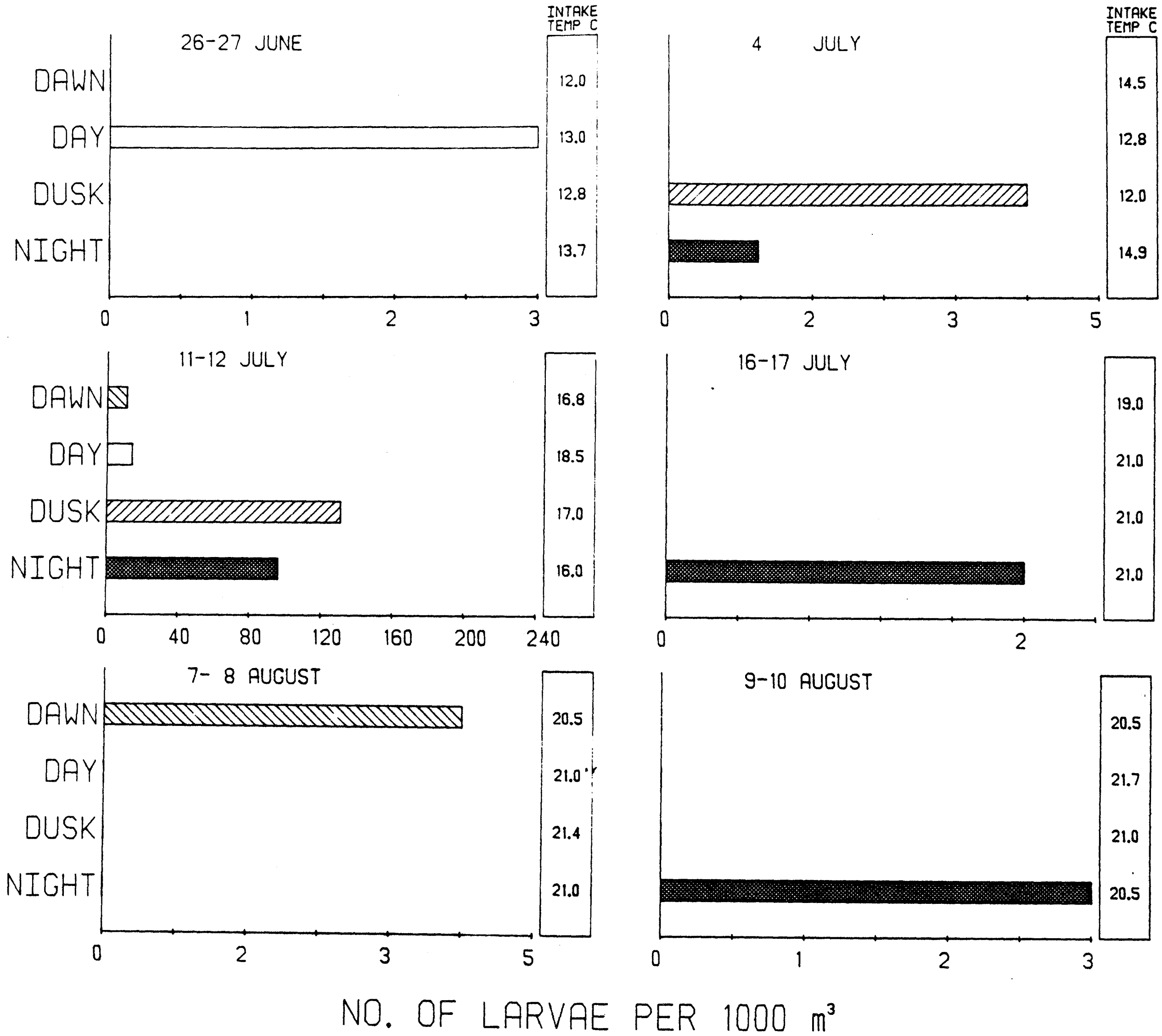


Fig. 78. Continued.

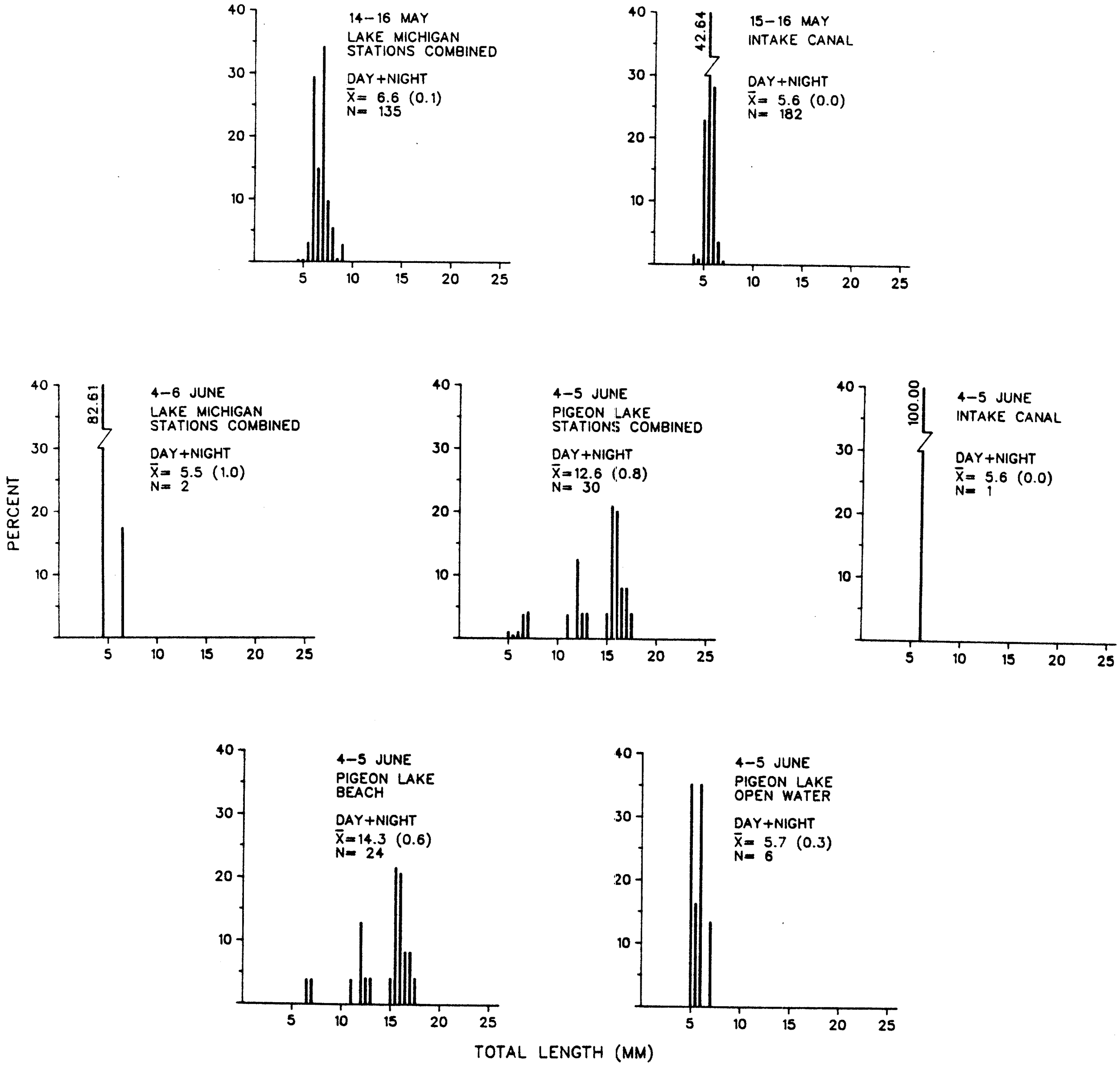


Fig. 79. Length-frequency histograms for larval yellow perch observed in Lake Michigan, Pigeon Lake and intake canal field samples during 1979 near the J. H. Campbell Plant, eastern Lake Michigan. All samples were collected with plankton net and sled tows. $\overline{X}$ = mean, N = total number of larvae, standard error is given in parentheses.

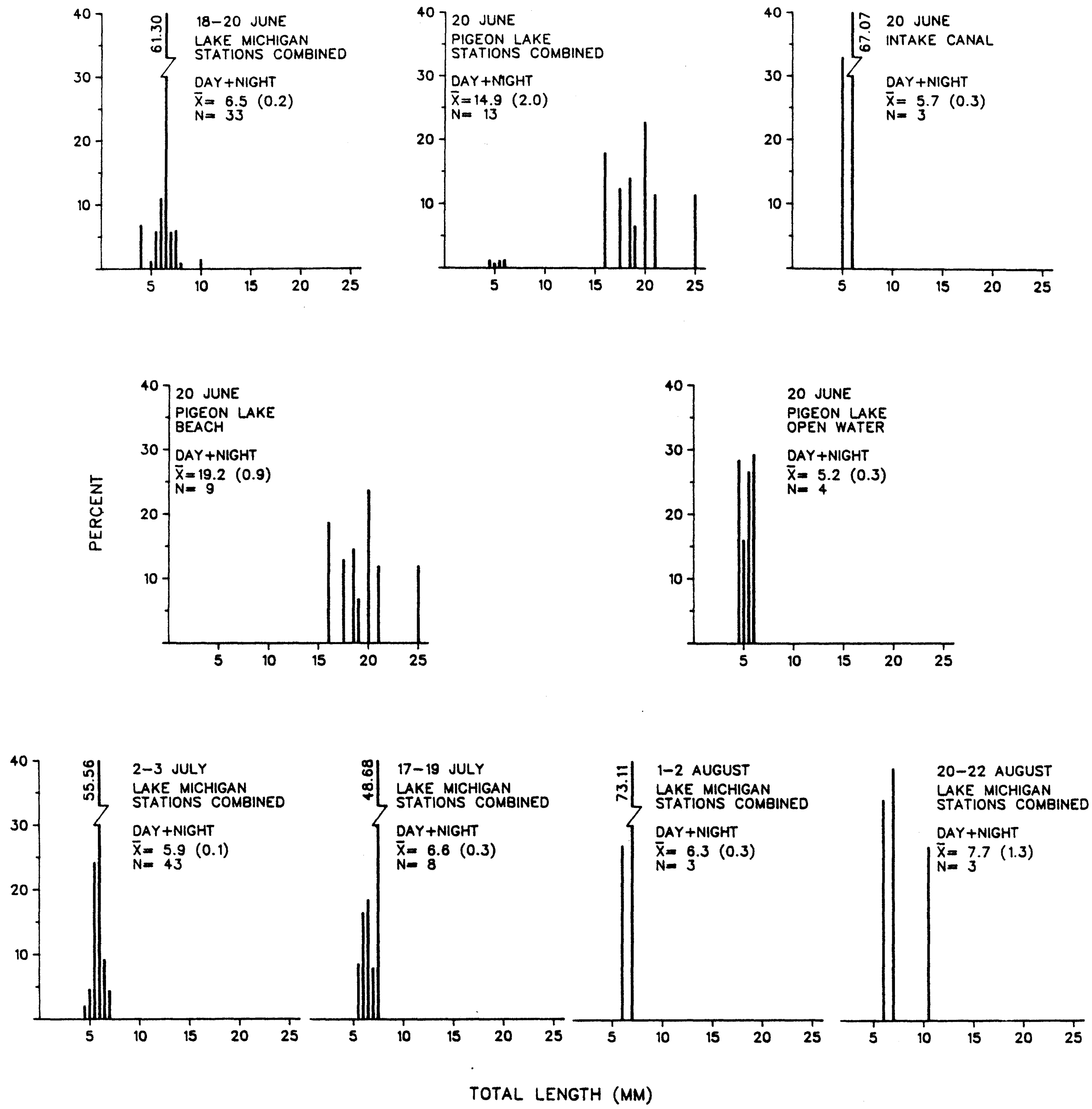


Fig. 79. Continued.

Most larval yellow perch collected in Pigeon Lake occurred at those stations undisturbed by water being drawn into the plant. Densities of larvae at stations V and X (undisturbed Pigeon Lake) reached $6360/1000\ m^3$ and $41,873/1000\ m^3$, respectively during night sampling. Water at these two stations (14.3-15.0 C) was warmer than at the remaining stations (12.3-13.8 C) in Pigeon Lake (Fig. 80). Although densities of larvae were lower at stations with cooler water temperatures, they were no less impressive, varying at night from a low of $60/1000\ m^3$ at the surface at station M (influenced by Lake Michigan) to a high of $1151/1000\ m^3$ at the surface at station Z (intake canal) (Fig. 80). A single 71-mm yearling was also collected at station V in a night plankton net tow (Appendix 15).

In Lake Michigan abundance of yellow perch larvae decreased with increasing depth and distance from shore. A similar observation was made in 1978 (Jude et al. 1979a). At the south transect, yellow perch larvae were most abundant at nearshore stations 3 m or less and none were recovered beyond 6 m (Fig. 81). Yellow perch larvae occurred in both day and night sled tows from the beach to 3 m. Because of their documented net avoidance capabilities, it was unexpected that day plankton and sled tows produced the most larvae at beach station P (south reference) and station A (1.5 m, south), respectively (Fig. 81).

Along the north transect, yellow perch larvae were observed at all stations except W (15 m, north) and were most abundant at nearshore stations 3 m or less (Fig. 81). At stations beyond 3 m, larvae were only obtained in upper strata tows 0.5 to 6.5 m. No larvae were recovered from depth strata greater than 6.5 m. Water temperatures were probably not responsible for this stratification as temperatures at the 6-, 9- and 12-m stations were fairly uniform (Fig. 81). Water temperatures were higher at stations 3 m or less and were slightly warmer at the north transect (14.6-12.5 C) compared to the south transect (13.8-11.5 C).

Catch of recently hatched (5.6-6.6 mm) yellow perch larvae during May in nearshore and beach zones matches that observed in 1978. We believe that yellow perch larvae found in Lake Michigan at this time resulted from drift from major streams and lakes which flow into Lake Michigan (Jude et al. 1979a), including possibly the discharge canal. Supplemental tows in May conducted within the discharge canal revealed yellow perch larvae were present there in large numbers. Wells (1973) also used this theory to explain presence of yellow perch fry in early May near Saugatuck, Michigan (32 km south of the Campbell Plant). Since longshore currents are strongest closest to shore, larvae could travel considerable distances and be concentrated in nearshore areas as we have observed.

Larvae observed during May in Lake Michigan were clearly not the result of adult fish spawning in Lake Michigan. Most adult perch were caught at 6 to 9 m or deeper (see Jude et al. 1979a and ADULT AND JUVENILE FISH-Yellow Perch, this report). These fish spawn on rocky substrates offshore when temperatures reach 8.9 to 12.2 C (Scott and Crossman 1973). Water temperatures near the bottom at the 6- to 9-m stations were just reaching these levels during May.

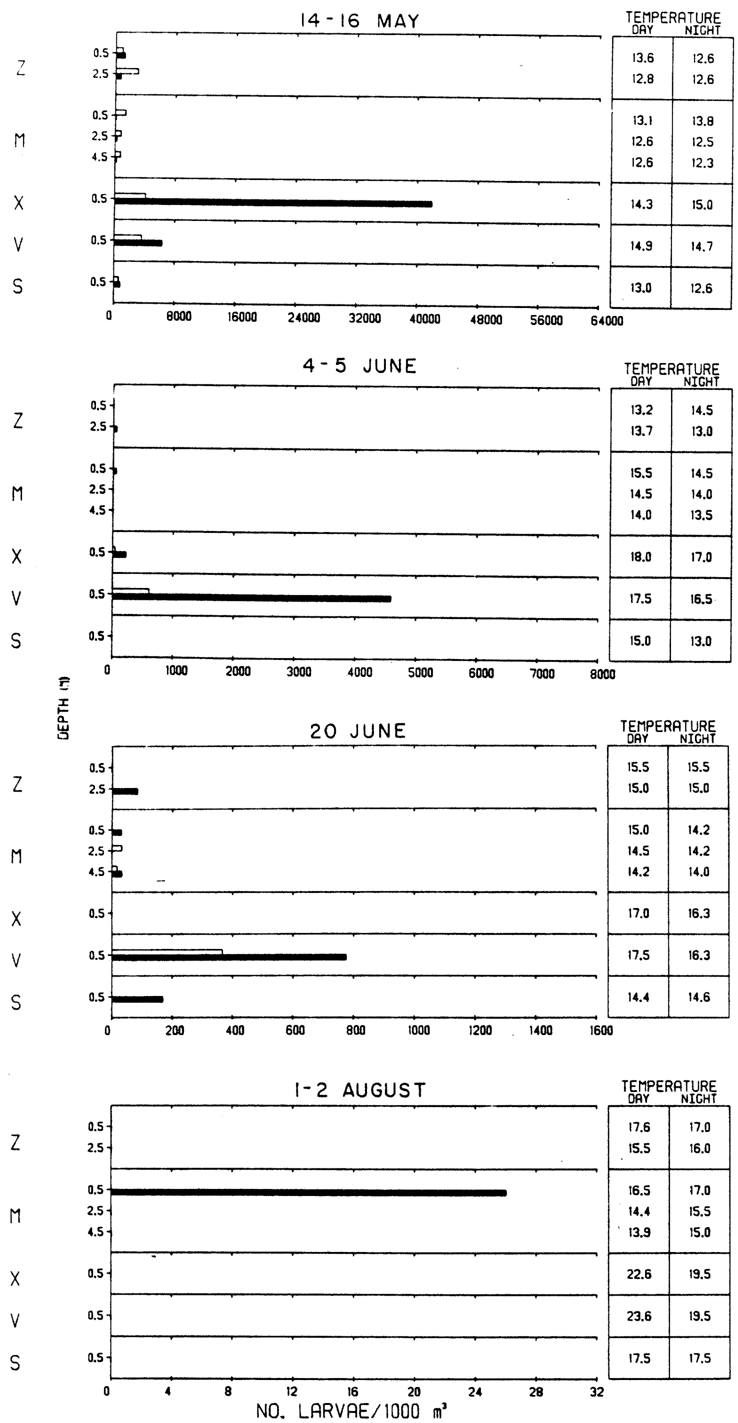


Fig. 80. Density of larval yellow perch (no./1000 m^3) at Pigeon Lake and intake canal stations near the J.H. Campbell Plant, eastern Lake Michigan, April to September 1979. Stations Z(intake canal), M(6 m, openwater), X(1 m, openwater), V(beach, undisturbed) and S(beach, Lake Michigan influenced) are shown. ☐ = day, ■ = night.

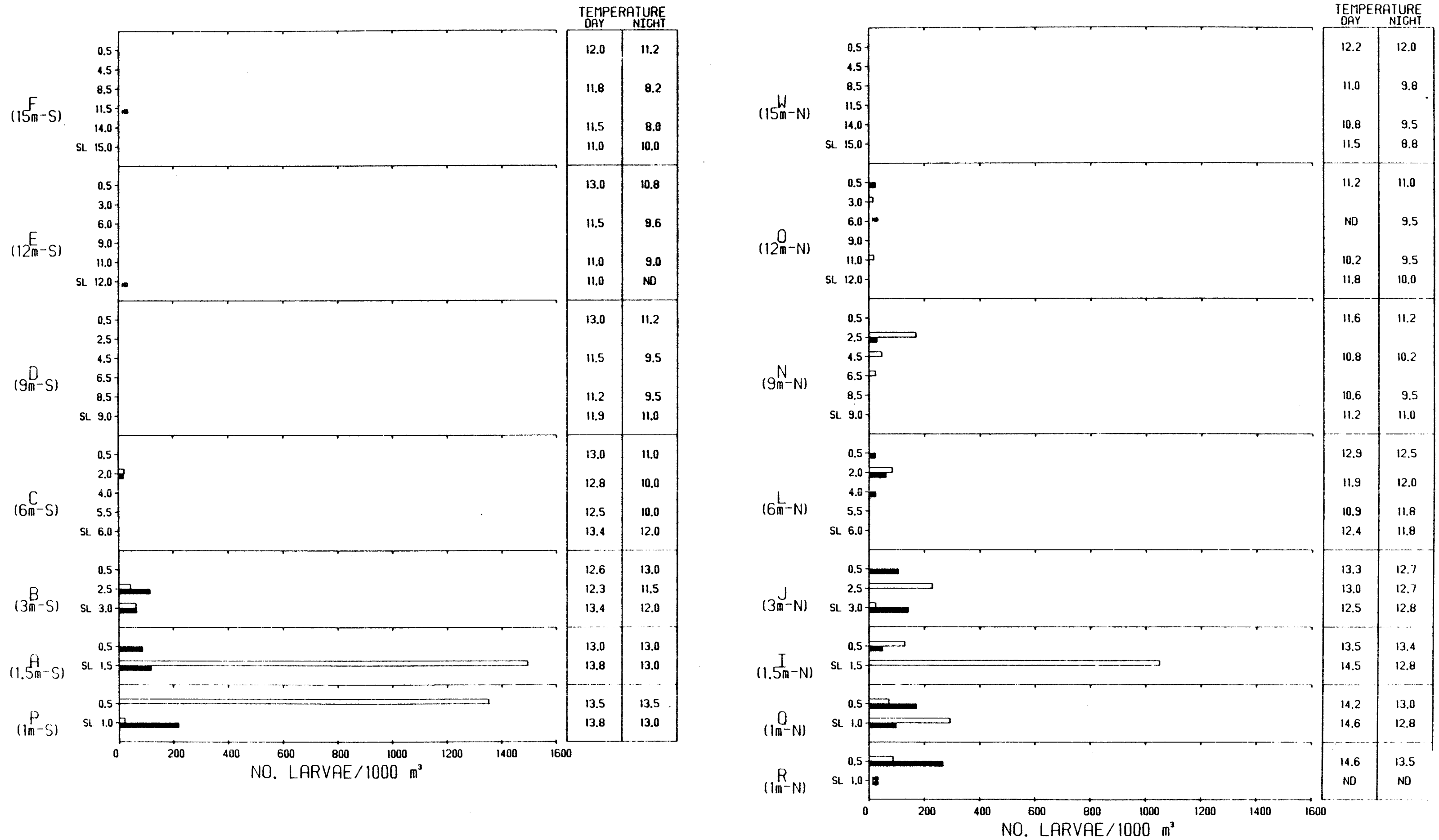


Fig. 81. Density of larval yellow perch (no./1000 m^3) at Lake Michigan stations near the J.H. Campbell Plant, eastern Lake Michigan, 14-16 May 1979. □ = day, ■ = night, SL = sled, ND = no data.

If adult perch began spawning during May at 8.3 C, the eggs would not hatch for approximately 30 days (Scott and Crossman 1973) giving a mid- to late June hatching date.

June--Larval yellow perch occurred in Lake Michigan, Pigeon Lake, intake canal and in entrainment samples from all 4 wk in June. Larvae occurred in much lower abundance compared to that observed in May. These data contrast with those of 1978 when no larval yellow perch were recovered from Pigeon Lake or intake canal samples.

Field sampling was conducted twice during June. In Pigeon Lake the first week of June, yellow perch larvae were predominately caught at stations V and X which are probably not influenced by the flow of water taken in by the plant. Greatest perch densities occurred at night, 4584/1000 m^3 at station V and 216/1000 m^3 at station X (Fig. 80). Only at night at stations M (influenced by Lake Michigan) and Z (intake canal) were any other yellow perch larvae collected. Densities averaged 50/1000 m^3 (Fig. 80). Average length of larval yellow perch collected in Pigeon Lake was 12.6 mm, but larvae from open water stations (M and X) averaged 5.7 mm (Fig. 79). Those at beach stations (S and V) averaged 14.3 mm suggesting that large yellow perch larvae were spawned in Pigeon Lake during April while smaller larvae were probably the result of yellow perch spawning in Lake Michigan in late May.

In the late June sampling period, yellow perch larvae were most abundant at beach station V (undisturbed Pigeon Lake), but none were collected at station X (undisturbed Pigeon Lake). Densities were greatest at station V during the night (775/1000 m^3). Several larvae were also collected by seine at station V, but since this was adult sampling gear and density determinations are speculative, these fish will be discussed under ADULT AND JUVENILE FISH-Yellow Perch. Three fry (26 to 28 mm) were incidentally caught in night plankton net tows at station V in late June (Appendix 15).

Elsewhere in Pigeon Lake, a few larval yellow perch were collected predominately at night at stations S and M (both influenced by Lake Michigan); however, densities were 150/1000 m^3 or less. A few yellow perch larvae also occurred at intake canal station Z (82/1000 m^3). By late June, larvae averaged 14.9 mm; however, smaller larvae (5.2 mm) occurred at open water stations M and X, while large larvae (19.2 mm) occurred at beach stations S and V (Fig. 79). Larvae collected at station Z (intake canal) were also small, ranging in length from 5.6 to 5.7 mm.

These data support the theory that two separate cohorts of yellow perch are produced: one from Pigeon Lake and one from Lake Michigan. As can be seen in Fig. 80, most larvae were either collected from beach station V (undisturbed Pigeon Lake) or open water station M (influenced by Lake Michigan). The larger larvae which occurred most often at station V (undisturbed Pigeon Lake) are probably those spawned in Pigeon Lake during May, while smaller larvae encountered at stations M and Z (both influenced by Lake Michigan) are individuals which arose from a more recent spawning in Lake Michigan.

Yellow perch larvae occurred only at two stations in Lake Michigan during early June. A density of 76/1000 m^3 was observed at station A (1.5 m, south) in a sled tow during the day and 16/1000 m^3 occurred at station N (9 m, north) in a 2-m night tow. Water temperatures were similar to those observed in May.

By the late June sampling period, yellow perch larvae were more frequent in Lake Michigan samples, but below abundance levels observed in May. In late June yellow perch larvae were predominately caught at depths greater than 3 m, just the opposite of what was observed in May (Fig. 82). Water temperatures at the time of sampling were warmer at the 6- to 15-m stations (Fig. 82) than the nearshore 0- to 3-m stations. These temperatures varied from 9.0 to 16.5 C at the south transect to 12.0 to 17.8 C along the north transect.

Larval yellow perch were randomly distributed in late June; however, most larvae were again collected at night. They were much more abundant in samples taken at the north transect where densities ranged from 1169 to 13/1000 m^3 than at the south transect where densities ranged from 132 to 14/1000 m^3 (Fig. 82). Secchi disc readings at the north transect (Fig. 82) indicated waters were less transparent, probably a result of dredging and discharge construction activity, thereby reducing net avoidance.

Length-frequency data resulting from entrainment sampling also revealed the existence of two different size groups of larval yellow perch (Fig. 77) during June. This will be further discussed in the ENTRAINMENT section.

July--Although sampling was conducted twice in July as it was in June, no larval yellow perch were collected from Pigeon Lake or the intake canal. A 39-mm fry was incidentally caught in a night plankton net tow at station V (Appendix 15) during late July. Entrainment of yellow perch was sporadic and reduced as well (Fig. 77). During the first sampling period, perch larvae in Lake Michigan occurred mostly at depths greater than 6 m (Fig. 83). Their occurrence was random at the south transect while at the north transect, yellow perch larvae were most abundant at 9- and 12-m stations in surface to 6-m tows (Fig. 83), particularly at night. Due to an apparent upwelling, water temperatures were low (5.0 to 12.7 C) averaging 9 to 11 C. Temperatures were slightly warmer at the north transect (Fig. 84); particularly at 6- and 9-m stations.

By late July, yellow perch larvae were uncommon in our samples. A few larvae were recovered at 3- and 6-m south transect stations and some were caught between the 6- and 9-m north transect stations. Although inshore water warmed from early July (7.3 to 14.5 C), offshore temperatures showed a decline (3.0-12.0 C) (Fig. 85). Again, temperatures were slightly warmer at the north transect (Fig. 84).

During early July, yellow perch larvae averaged 5.9 mm while in late July, the average length had increased to 6.6 mm (Fig. 79). These larvae, which occurred at stations deeper than 3 m, particularly those seen in the first week of July, are those which originated from a Lake Michigan spawning. These data compare favorably with those of 1978; however, fewer larvae were

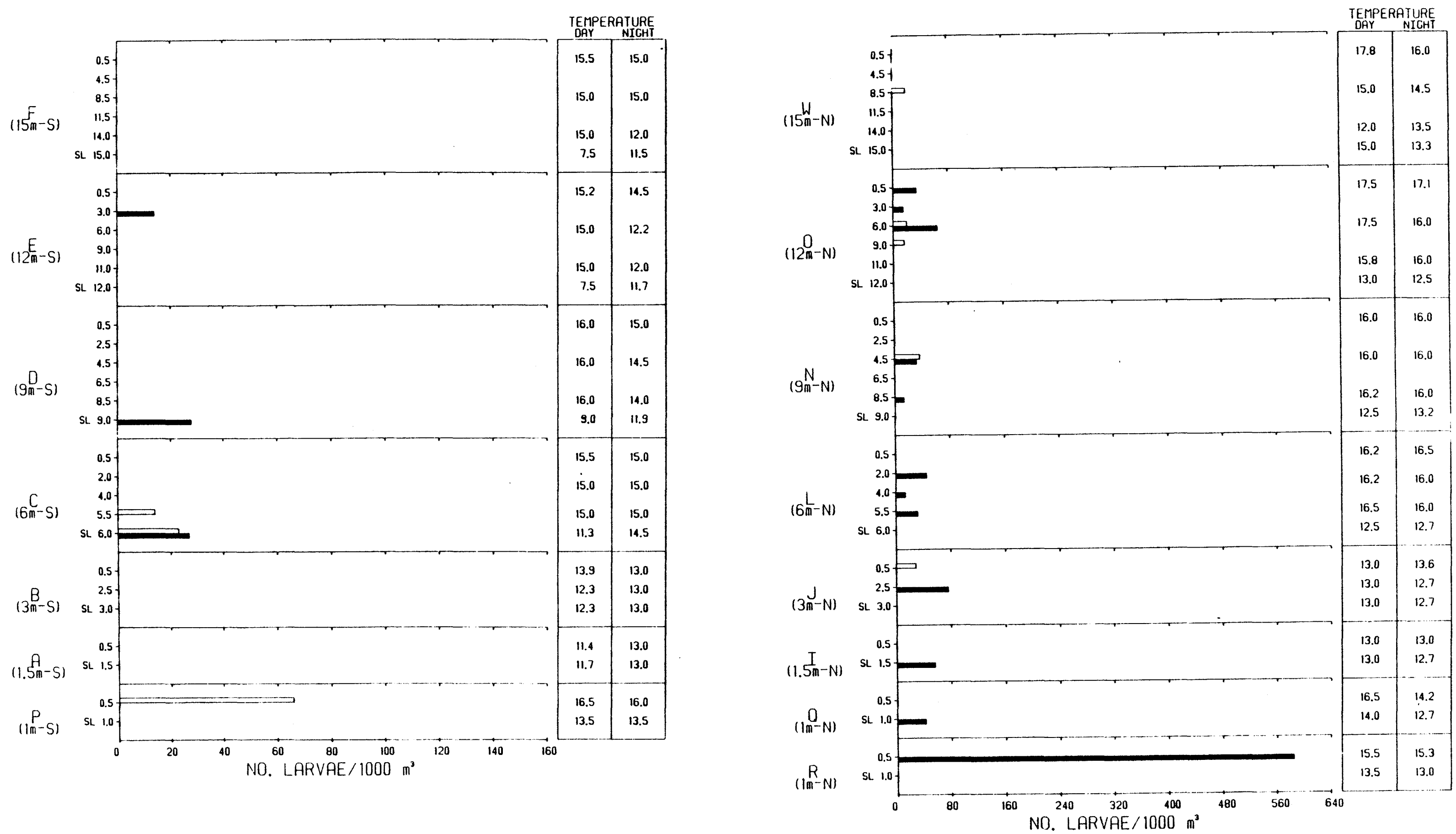


Fig. 82. Density of larval yellow perch (no./1000 m^3) at Lake Michigan stations near the J.H. Campbell Plant, eastern Lake Michigan,18-20 June 1979. ▢ = day, ■ = night, SL = sled, ND = no data.

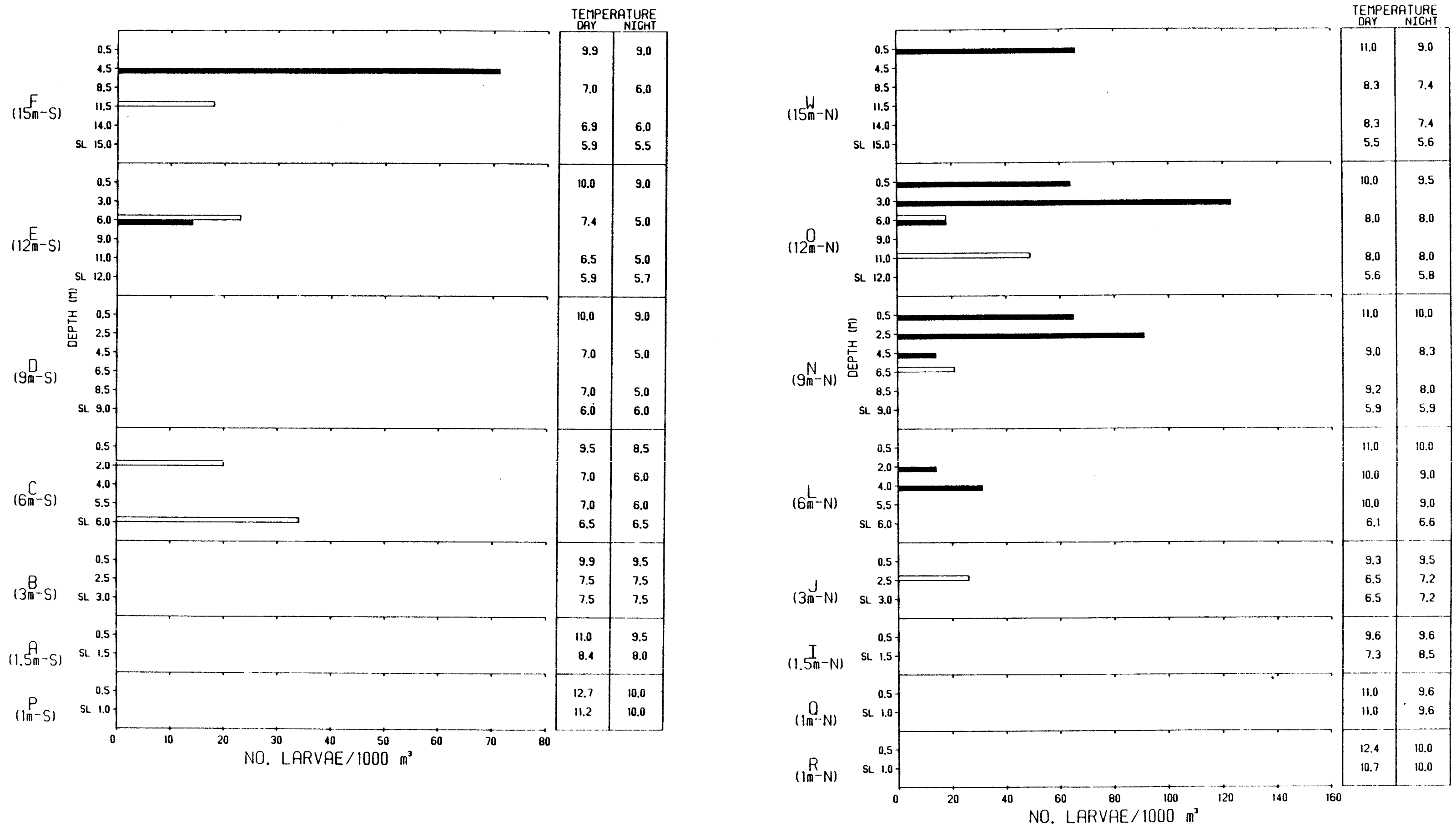


Fig. 83. Density of larval yellow perch (no./1000 m^3) at Lake Michigan stations near the J.H. Campbell Plant, eastern Lake Michigan, 3-4 July 1979. ☐ = day, ■ = night, SL = sled, ND = no data.

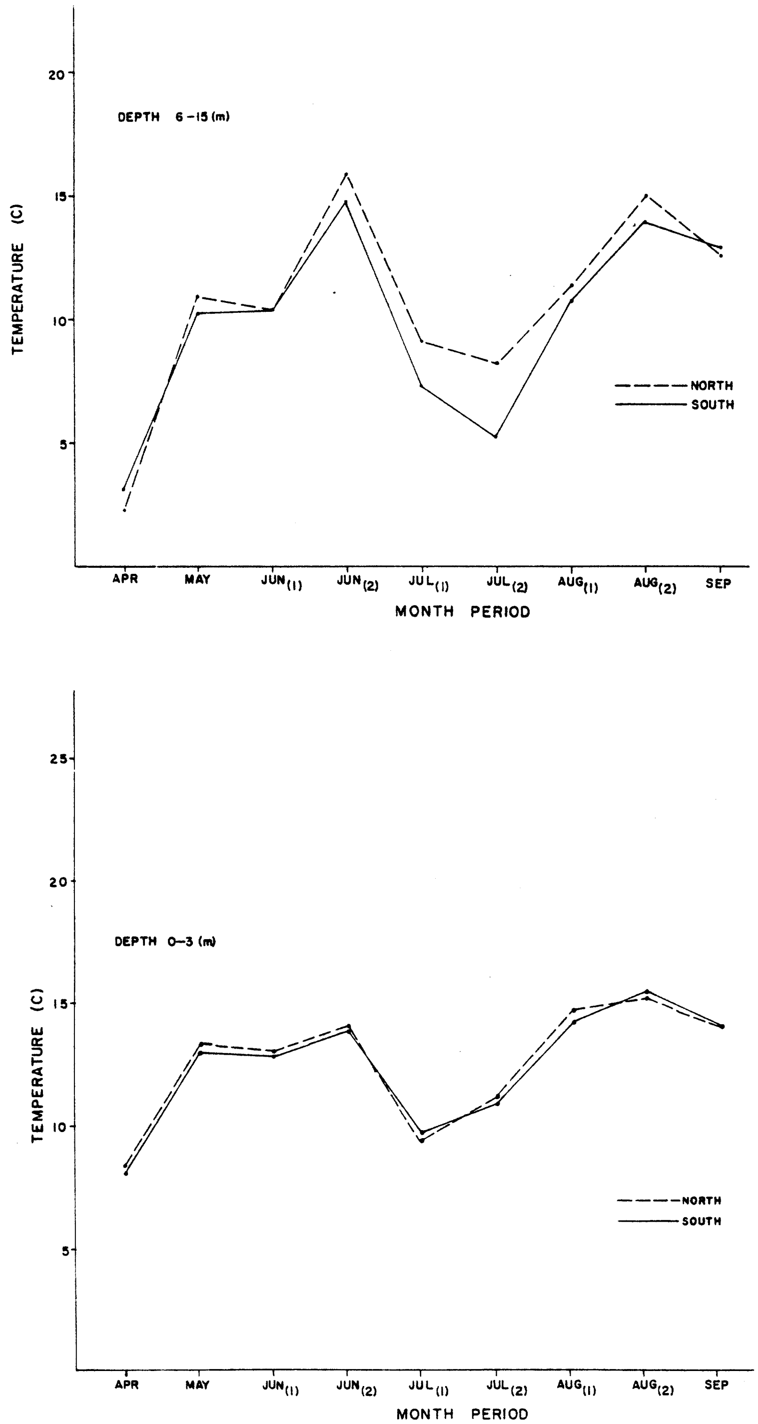


Fig. 84. Average water temperatures at inshore stations (0-3 m) and offshore stations (6-15 m) for all 1979. Temperatures at each stratum for both day and night tows were pooled.

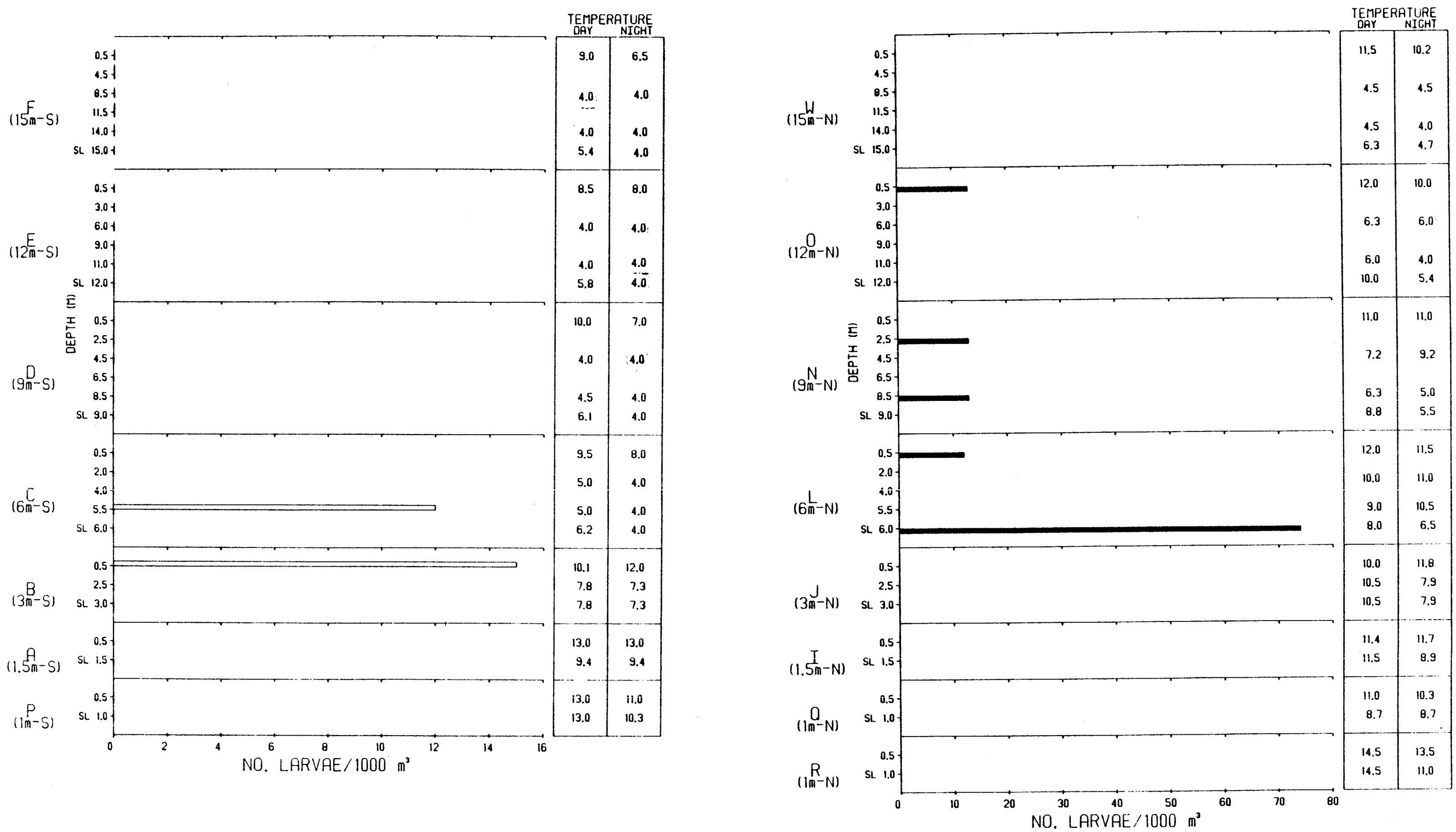


Fig. 85. Density of larval yellow perch (no./1000 m^3) at Lake Michigan stations near the J. H. Campbell Plant, eastern Lake Michigan, 16-19 July 1979. □ = day, ■ = night, SL = sled, ND = no data.

encountered in 1979. The upwelling observed during July coupled with reduced numbers of adult perch which were apparent from our adult sampling efforts (see ADULT AND JUVENILE FISH-Yellow Perch), may be responsible for the reduced catch of perch larvae in Lake Michigan.

Larvae were entrained during the first 2 wk of July only. These larvae averaged 6.5 mm and again were probably the result of Lake Michigan spawnings (Fig. 77).

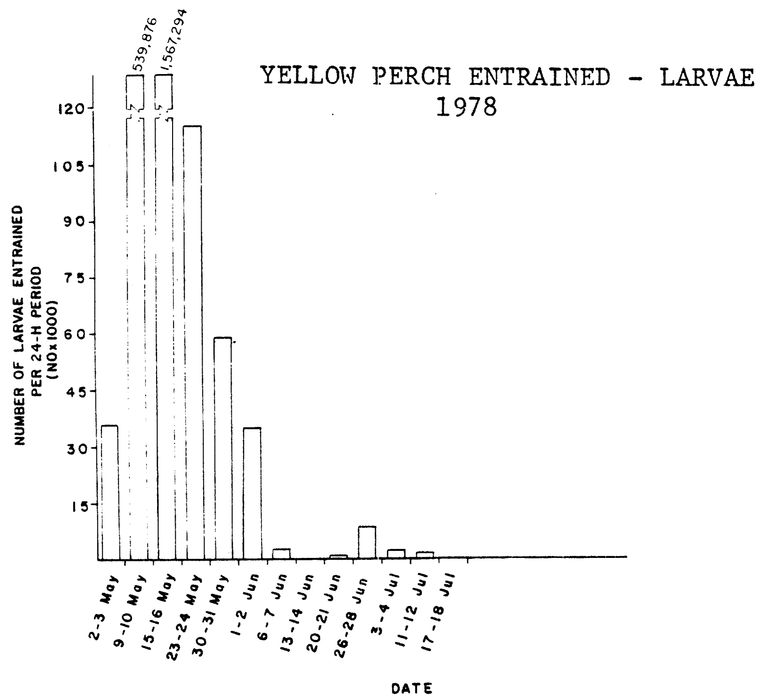
August--By August, yellow perch larvae occurred randomly throughout the study area. This was the last month in which they were caught in plankton net and sled gear. A density of 26/1000 m³ was observed in a night surface tow at Pigeon Lake station M (influenced by Lake Michigan) (Fig. 80). During both sampling periods in August, a few larvae were caught at 12- and 15-m stations at both transects (Appendixes 10 and 11). A few larvae were also seen in a beach station Q night sled tow (Appendix 10). By August, water temperatures had warmed considerably with north transect stations having slightly higher temperatures than the south transect (Fig. 84). Again, the 6- and 9-m north transect stations were much warmer than comparable south transect stations. Low densities of 4/1000 m³ and 3/1000 m³ were observed during the first 2 wk of entrainment sampling (Fig. 78). Fry once again were incidentally caught in night plankton net tows during early August and mid-September. These seven fish ranged from 39 to 71 mm and were all caught at stations V and X (Appendix 15).

Entrainment--

Entrainment of larval yellow perch began 1 wk earlier during 1979 than it did in 1978. Yellow perch larvae were entrained during all four time periods the last week of April at densities of 2 to 28/1000 m³ (Fig. 78). More larvae were entrained during the night than during the day. These larvae averaged 5.7 mm and were probably the outcome of spawning in Pigeon Lake (Fig. 77).

Peak numbers of larval yellow perch were entrained during May (Fig. 86). Yellow perch larvae were entrained during all time periods each of the 4 wk (Fig. 78). The greatest number of larvae was recovered during the third and fourth weeks. During the second week of May, when entrainment was substantial in 1978, the plant was not in operation and no sampling was conducted. During the third week of May, projected 24-h entrainment rates reached 977,139 larvae (Fig. 86). This figure matches closely the 1,567,294 larvae estimated to have been entrained over a 24-h period during the same week in 1978 (Fig. 86). During the first 3 wk of May, water temperatures ranged from 8.5 to 13.0 C, while during the last 2 wk when entrainment decreased, temperatures were between 9.4 and 10.0 C (Fig. 78).

The number of yellow perch entrained decreased throughout June (Fig. 78). Larval yellow perch were entrained during all four time periods in the first week, but were erratic in appearance and low in abundance during the following weeks (Fig. 78). Average length of yellow perch larvae entrained in June was 7.2 mm (Fig. 77). A closer examination of entrainment results by



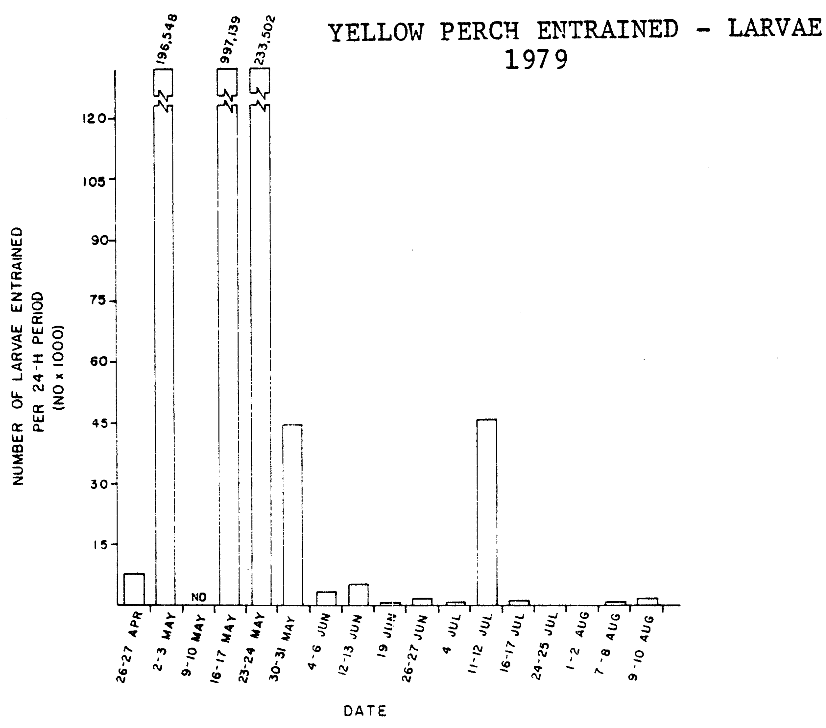


Fig. 86. Total number of yellow perch larvae entrained during a 24-h period projected from densities observed in the 16 samples collected weekly at the J. H. Campbell Plant, eastern Lake Michigan, 1978 and 1979. ND = no data.

week revealed two size groups in the second week of June (Fig. 77). Smaller fish ranging from 5.5 to 6.0 mm were probably from spawnings in Lake Michigan while the larger group (11.5 to 14.0 mm) (Fig. 77) was probably composed of older fish spawned in Pigeon Lake.

Although there were no larval yellow perch recovered from Pigeon Lake or intake canal samples during July, several larval yellow perch were entrained the second week (Fig. 78). Projected entrainment rate over a 24-h period during that week was 45,640 larvae (Fig. 77). Entrainment of larval yellow perch declined drastically after that week. During July and August entrained larvae averaged 6.5 and 5.7 mm, respectively and probably arose from spawnings in Lake Michigan (Fig. 77). One other yellow perch was entrained in 1979. This 77.0-mm fry was caught in an early March sample and was probably a yearling spawned in 1978 (Appendix 15).

Summary--

Although yellow perch larvae were the second-most abundant species of larvae in the study area during 1979, the increase seems to be specific to Pigeon Lake. Abundances of larval yellow perch were generally lower in Lake Michigan and in the entrained population sampled during 1979 compared with results seen in 1978. Entrainment of yellow perch during 1979 was estimated to have reached 14.6 million larvae while in 1978 16.1 million larvae were entrained.

As was hypothesized in 1977, two cohorts of yellow perch larvae were observed in the study area. Those resulting from spawnings in Pigeon Lake were entrained during May and found in Pigeon Lake as well as the inshore zone of Lake Michigan. Some of these larvae may have resulted from spawnings within the discharge canal since it was open to Lake Michigan. Later spawning in Lake Michigan accounted for the small larvae seen in Lake Michigan during June and July. These larvae became susceptible to entrainment by the second week of June.

In Pigeon Lake most yellow perch larvae were recovered at undisturbed stations V and X during May. These stations generally had warmer water temperatures, since they were unaffected by the cooler water of Lake Michigan being drawn in by the plant. In Lake Michigan water temperatures were slightly higher at the north transect and during May, June and July yellow perch larvae were clearly more abundant at this transect. The fact that Secchi disc readings were lower at the north transect, indicating less water clarity, may account for less net avoidance and therefore greater catches near this area of disturbance.

Since field and entrainment sampling began late in 1977, population abundances and distributions particular to yellow perch in May and June were missed and since stations T and Y were deleted from our scheme after that year, it is difficult to compare sampling results in 1977 with those found in 1978 or 1979.

Cyprinidae Complex

Introduction--

As during previous years, cyprinids were the most difficult fish larvae to identify. Expanded field collections and increased expertise has made possible a drastic reduction in the number of cyprinids classified as unidentified minnows (XM) in 1979 compared with 1977 and 1978 samples. The following discussion presents the distributional patterns by species of all larval cyprinids caught near the Campbell Plant in 1979. Cyprinids classified as unknown minnows will also be discussed with speculations as to their identity.

Spottail shiner--

Seasonal distribution--The first indication of spottail spawning near the Campbell Plant in 1979 was a 4.0-mm larva caught at Lake Michigan beach station Q (south discharge) in April. This larva undoubtedly came from the discharge canal since Lake Michigan water temperatures were too low to allow spottail spawning. The resulting density of spottail larvae at the station was 24 larvae/1000 m³. During the following two sampling periods (14-17 May and 4-6 June) spottail shiner larvae were only observed at north transect stations (Fig. 87), suggesting that spawning in the area near the discharge might have preceded that of the Lake Michigan areas unaffected by the thermal discharge. Spottail larvae caught in Lake Michigan at these times were small (less than 6 mm) and probably newly hatched (Fig. 88). It is possible that spawning of spottails could be occurring during April-June in the discharge canal itself, and that larvae were being washed into Lake Michigan.

Spawning in Pigeon Lake during May was indicated by the presence of small, newly hatched larvae at beach station S (influenced by Lake Michigan) (Fig. 89). This station was typically an area of intense minnow spawning from May to August of all years.

The first major occurrence of spottail shiner larvae at Lake Michigan stations was during late (18-20) June. Larvae were primarily distributed at depths of 3 m and less (Fig. 90), although low densities (less than 40 larvae/1000 m³) were observed at 6- and 9-m north transect stations (Appendix 10). As during early June, the majority of larvae caught in Lake Michigan in late June were small (5 mm or less) indicating that they were newly hatched.

Intense spottail spawning/hatching activity in Pigeon Lake during June was indicated by extremely high densities (over 10,000 larvae/1000 m³) of spottail larvae at beach station S (influenced by Lake Michigan - Fig. 89). Station V (undisturbed Pigeon Lake) was also used as a spawning site as densities of nearly 2000 spottail larvae/1000 m³ were observed there in late June (Fig. 89). These data concurred with June 1978 findings, which showed densities as high as 130,000 larvae/1000 m³ at station S. Length-frequency data from Pigeon Lake stations in late June (Fig. 88) showed a high percentage

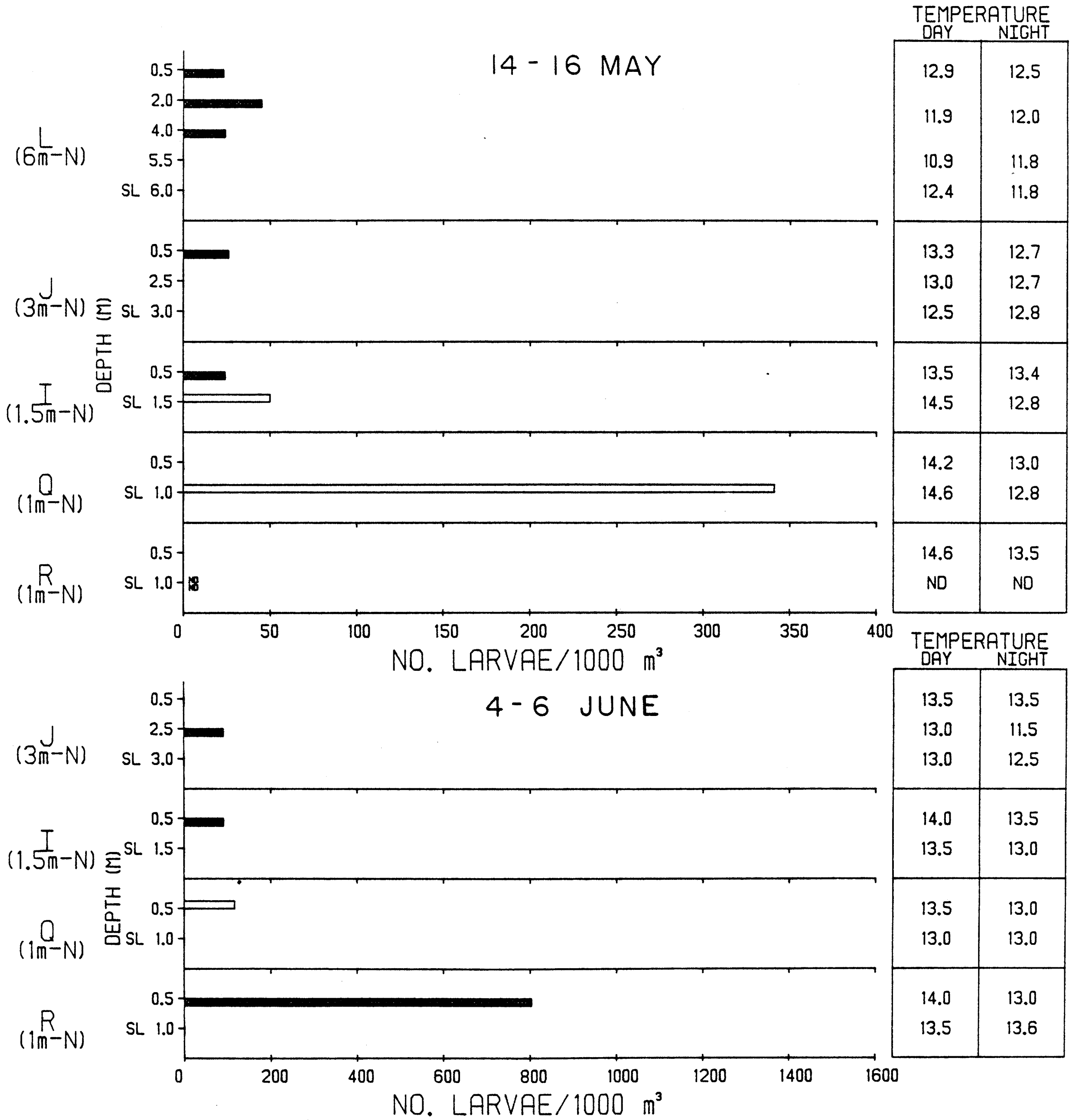


Fig. 87. Density of larval spottail shiners (no./1000 m^3) at Lake Michigan stations near the J.H. Campbell Plant, eastern Lake Michigan, 14-16 May and 4-6 June 1979. No larvae were collected at stations omitted.
□ = day, ■ = night, SL = sled.

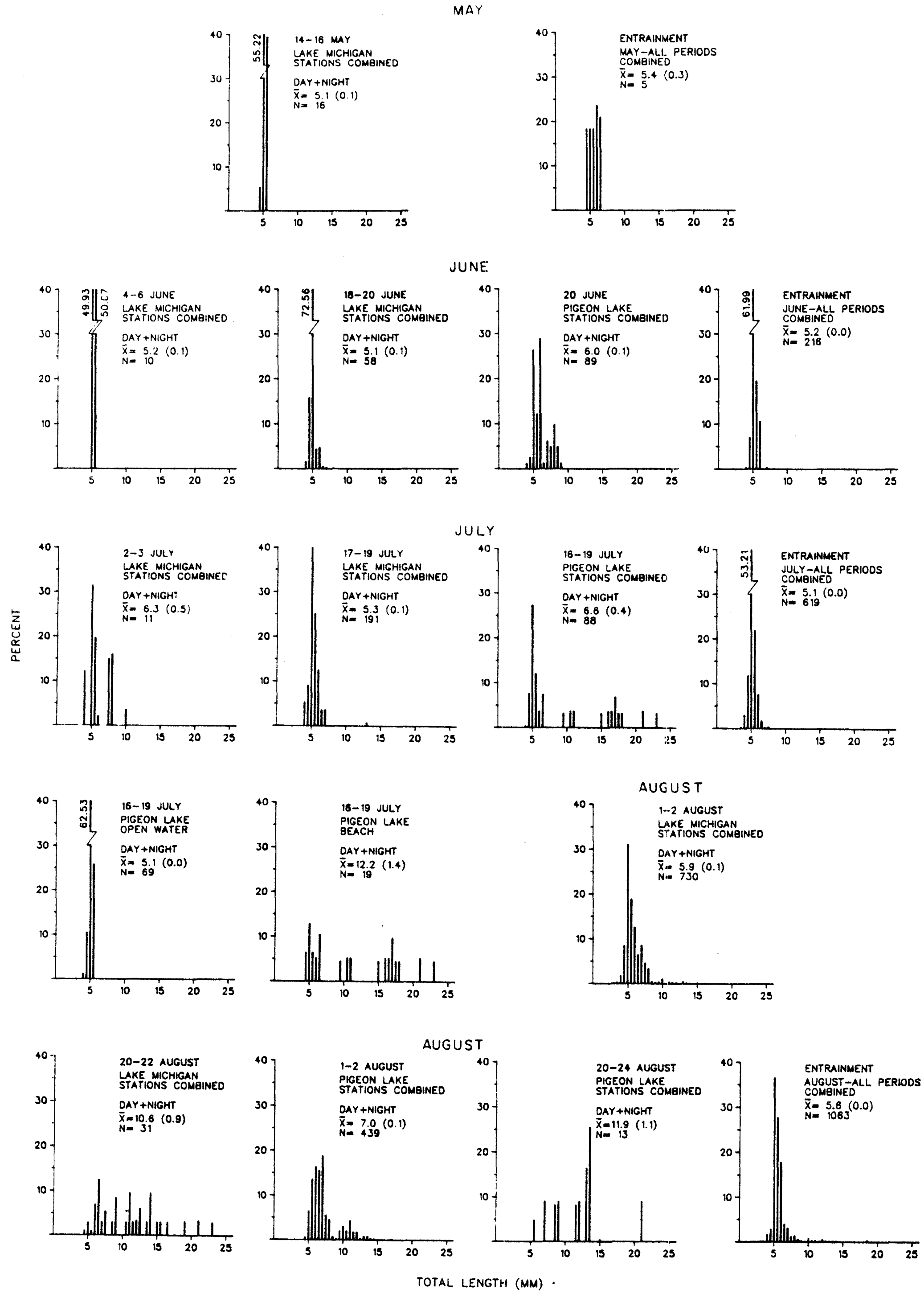


Fig. 88. Length-frequency histograms for larval spottail shiners in field and entrainment samples collected during 1979 near the J.H. Campbell Plant, eastern Lake Michigan. Data from plankton net and sled tows were combined. $\overline{X}$ = mean, N = total number of larvae, standard error is in parentheses.

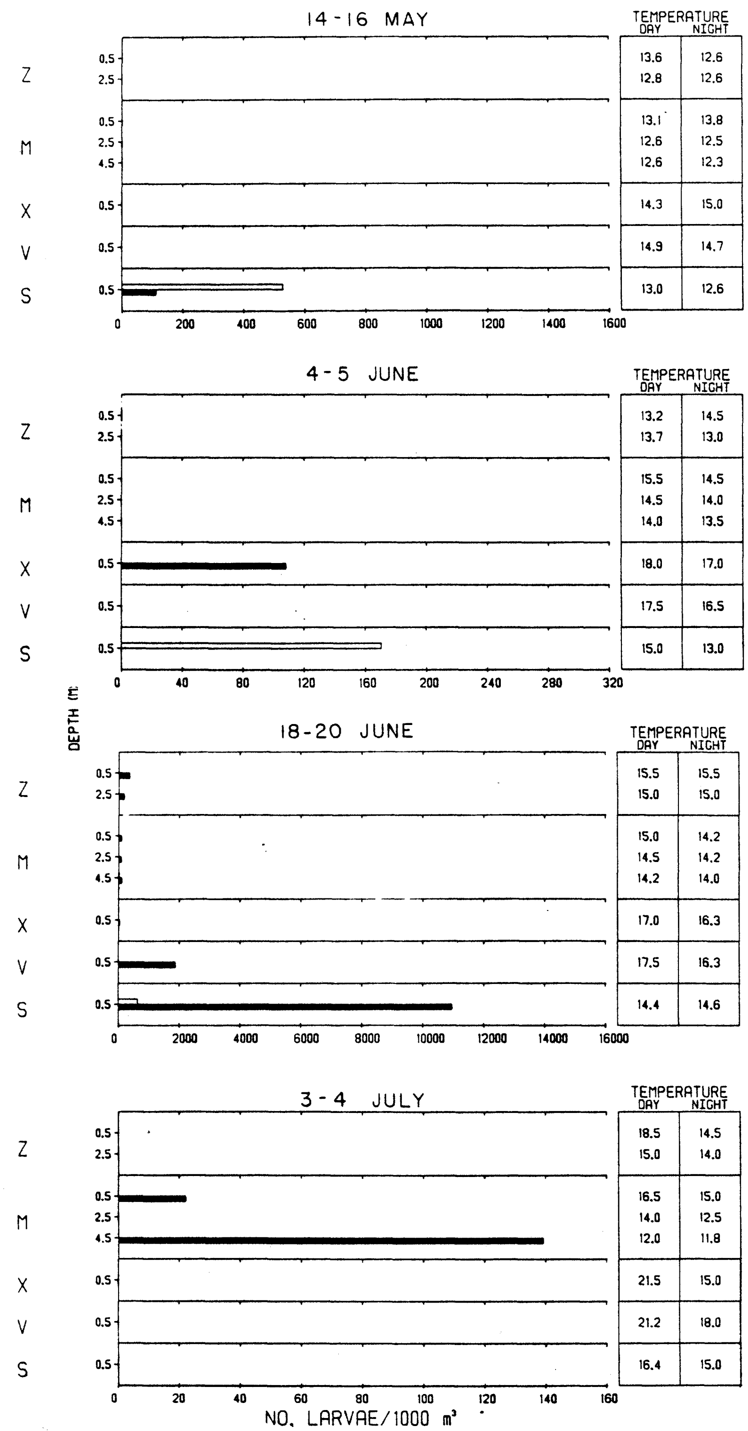


Fig. 89. Density of larval spottail shiners (no./1000 m^3) at Pigeon Lake and intake canal stations near the J.H. Campbell Plant, eastern Lake Michigan, April to September 1979. Stations Z(intake canal), M(6 m, openwater), X(1 m, openwater), V(beach, undisturbed) and S(beach, Lake Michigan influenced) are shown. □ = day, ■ = night.

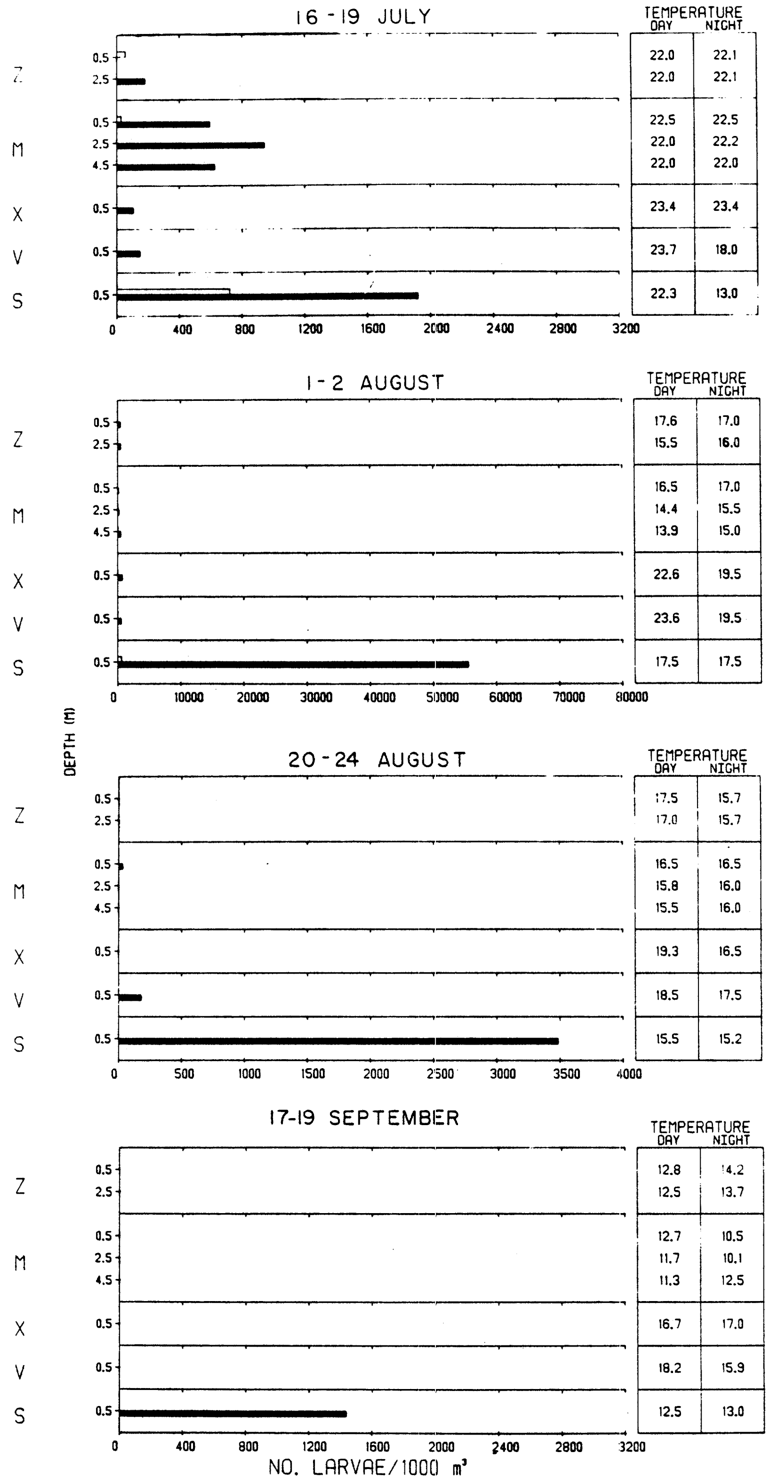


Fig. 89. Continued.

of newly hatched (4-6 mm) larvae as well as a complement of larger larvae, suggesting substantial hatching was probably occurring in Pigeon Lake throughout the later half of June.

An upwelling of cooler water in early July apparently caused an interruption of spottail spawning at Lake Michigan stations as densities at north transect stations were substantially reduced (Fig. 91) compared with late June (Fig. 90) values. In addition, no larval spottails were caught at south transect stations. Absence of spottail larvae at south transect stations in early July, along with their obvious nearshore (1.5 m and less) distribution at north transect stations, again implies that during times when Lake Michigan water temperatures were not conducive to spottail spawning, spottails may have continued to spawn in the discharge canal. Larvae spawned there may wash out into Lake Michigan, and depending on direction of the alongshore current, will be dispersed either north or south of the plant.

Although temperatures conducive to spottail spawning were observed at Pigeon Lake beach stations in early July, no larval spottails were caught there. The reason for this is not known. Open water station M (influenced by Lake Michigan) samples indicated densities of 0-140 larvae/1000 m^3 suggesting that some spottail spawning may have been occurring in Pigeon Lake in early July.

During late July, there were increased densities of spottail larvae at all Lake Michigan stations 3 m and less (Fig. 92) indicating resumed spottail spawning. Mean size of larvae caught at this time at Lake Michigan stations was 5.3 mm (SE = 0.1) suggesting that most were recently hatched (Fig. 88). As has been typical in all years sampled, when spottail larvae are present at north and south transects, they were typically more abundant at north stations near the discharge.

Pigeon Lake sampling during late July showed that a substantial increase in hatching activity of spottails compared with early July had occurred, as evidenced by increased larval densities. Many of these larvae were 6 mm or less indicating recent hatching (Fig. 88). A comparison of larvae caught at open water and beach stations in Pigeon Lake (Fig. 88) indicates that all larvae caught at open water stations were newly hatched ($\bar{x}$ = 5.1 mm, SE < 0.1), although beach sampling showed a wide range of sizes present ($\bar{x}$ = 12.2 mm, SE = 1.4). The reason for this may be that smaller larvae observed at open water station M are being passively swept from shoreline areas in Pigeon Lake or being drawn in from Lake Michigan; whereas, the larger larvae are able to remain in the shallower areas of Pigeon Lake. A similar pattern was observed for spottails at the Cook Plant, southeastern Lake Michigan (Jude et al. 1979b).

Highest densities of spottail larvae observed during 1979 at all Lake Michigan stations and at Pigeon Lake station S (influenced by Lake Michigan) were noted in early August. Spottail larvae were primarily distributed at depths 1-3 m in Lake Michigan (Fig. 93), although sporadic occurrences of lower densities at deeper stations were observed (Appendixes 10 and 11). Confinement of spottail larvae to the 1.5- and 3-m depths near the discharge

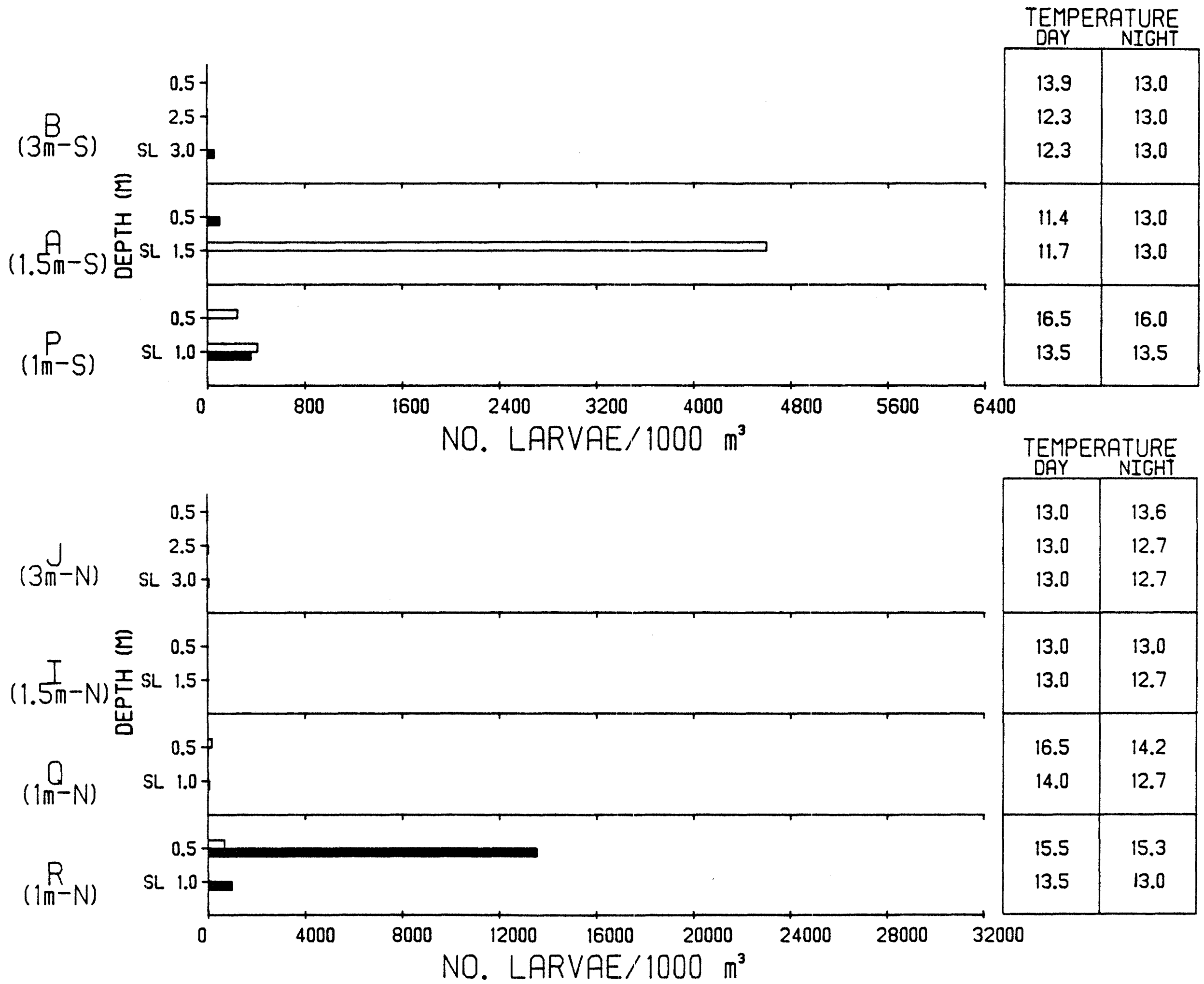


Fig. 90. Density of larval spottail shiners (no./1000 m^3) at Lake Michigan stations near the J.H. Campbell Plant, eastern Lake Michigan, 18-20 June 1979. Stations with densities less than 31/1000 m^3 were omitted.
□ = day, ■ = night, SL = sled.

was not observed to the same extent at south transect stations (Fig. 93). This may be caused by increased mixing and turbulence of water near the discharge dispersing larvae to slightly deeper water. Length-frequency data indicated that many of the larvae caught (over 50%) were 6 mm or less and probably recently hatched (Fig. 88). Clearly, major spawning of spottail shiners in Lake Michigan near the Campbell Plant occurred during latter July. Pigeon Lake length-frequency data of early August showed comparatively higher percentages of larger (10 mm and larger) larvae compared with Lake Michigan, suggesting that less intense recent spottail hatching was occurring, contributing to an increased dominance of older (larger) larvae in Pigeon Lake (Fig. 88).

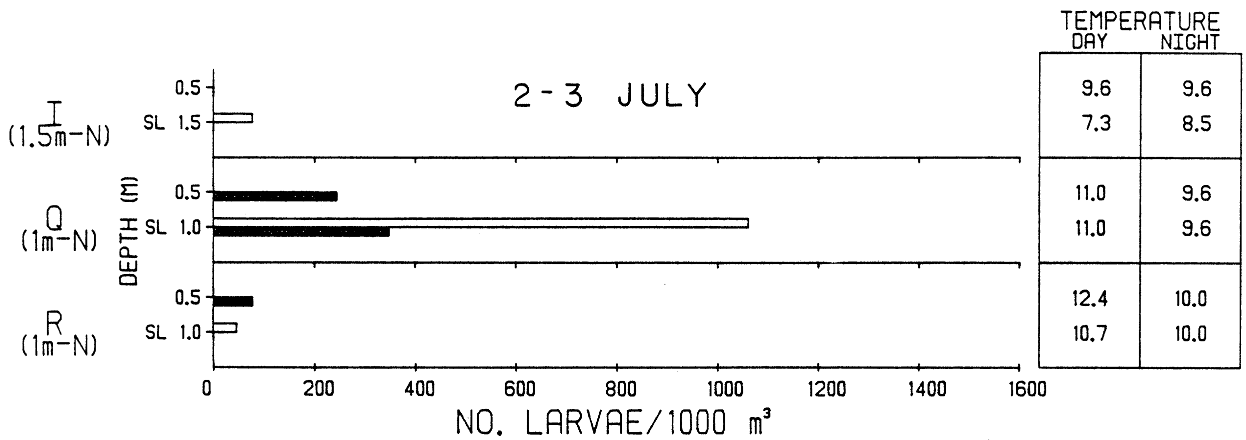


Fig. 91. Density of larval spottail shiners (no./1000 m^3) at Lake Michigan stations near the J.H. Campbell Plant, eastern Lake Michigan, 2-3 July 1979. Stations 3-15 m north and all south transect stations, were omitted due to absence of larvae in samples. □ = day, ■ = night, SL = sled.

Late August collections showed a marked decrease in the densities of spottail larvae at Lake Michigan stations. Distribution of larvae was generally at beach stations of both transects, and as in previous months, out to 3 m at north transect stations (Fig. 94). Sporadic low densities of larvae at deeper stations in Lake Michigan were also observed in late August.

The relatively low percentage of small (6 mm and less) larvae in late August samples (Fig. 88) suggests that little hatching occurred in Lake Michigan in late August. Similar conclusions could be inferred from Pigeon Lake length-frequency data (Fig. 88). Increased size of spottail larvae in late August could, in part, account for the lower densities. Although the exact length at which a spottail larva can avoid our nets is unknown, it is probable that at lengths exceeding 10 mm, spottail larvae exhibit a significant decrease in vulnerability to our gear.

Similar to what was found during 1977-1978, spottail larvae were not caught at Lake Michigan stations in September, probably owing primarily to growth of fish and increased net avoidance. Also comparable to previous years, spottail larvae were observed in Pigeon Lake in September at beach station S (influenced Lake Michigan) (Fig. 89).

<u>Entrainment</u>--In general, the maximum entrainment of spottail shiner larvae occurred from mid-July to mid-August (Fig. 95), coinciding with peak densities in field samples. Low densities of spottail larvae in entrainment samples from late May to 12 June (Fig. 96) resulted in relatively low (less than 10,000 entrained/24-h period) entrainment losses. A substantial peak in larval densities on 19 June resulted in the loss of over 68,000 spottail larvae in that 24-h period. From the 26-27 June sampling period to 16-17

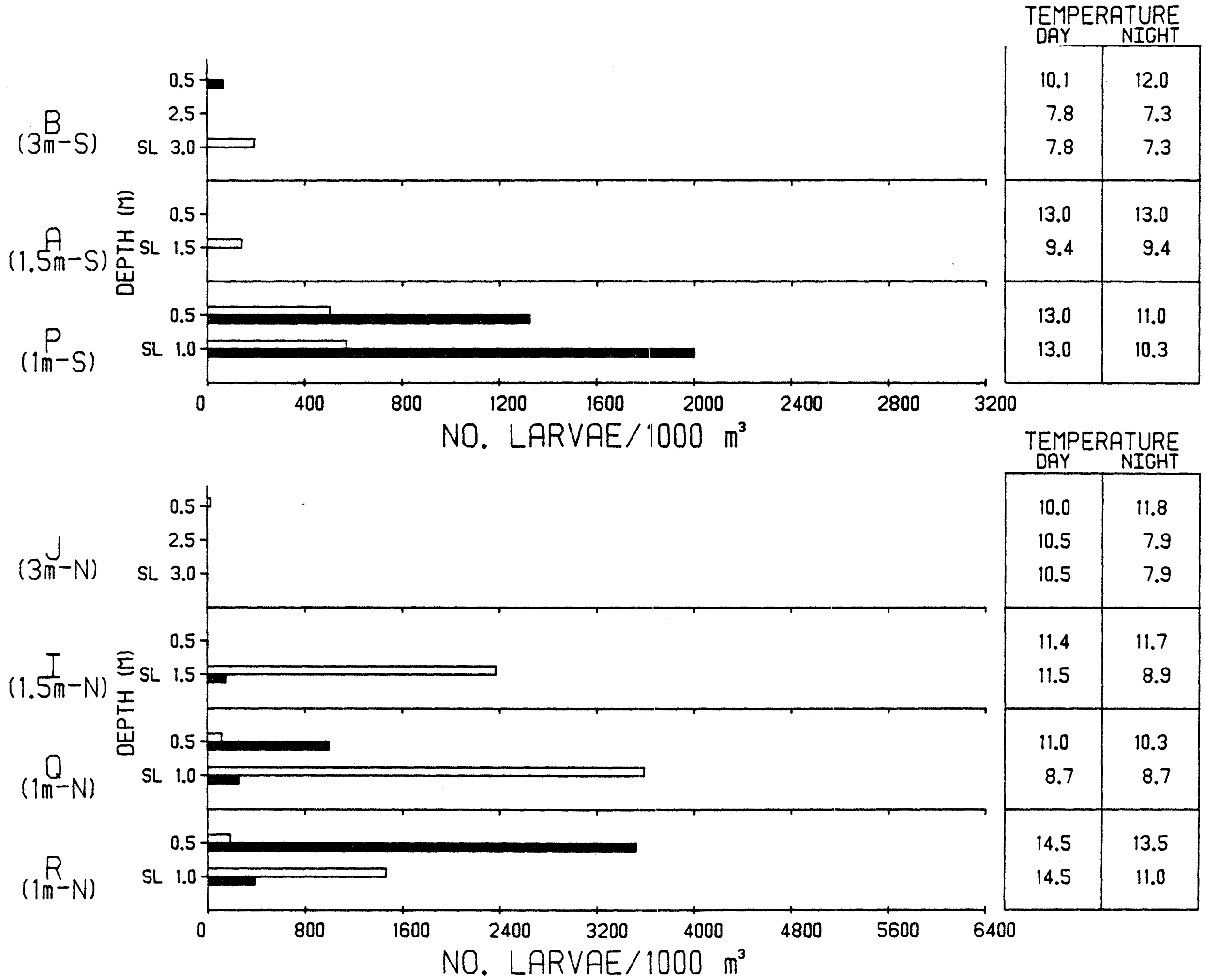


Fig. 92. Density of larval spottail shiners (no./1000 m^3) at Lake Michigan stations near the J.H. Campbell Plant, eastern Lake Michigan, 17-19 July 1979. Stations 6-15 m south and 6-15 m north were omitted due to absence of larvae in samples. ☐ = day, ■ = night, SL = sled.

July, densities of spottail showed steady increases (Fig. 96) resulting in increased entrainment losses until the peak of over 467,000/24 h on 16-17 July. A substantial decrease to over 75,000/24-h period was observed on 24-25 July, followed by losses of over 220,000/24-h period on the 1-2 and 7-8 August sampling dates. Entrainment of spottail larvae for the following three August sampling dates (9-10, 13-14, 15-16) remained high, with a dramatic decrease noted during sampling on 21-28 August. Only one occurrence, 16-17 October, of spottail larvae was observed from September to November; an estimated 600 larvae/24-h period were entrained.

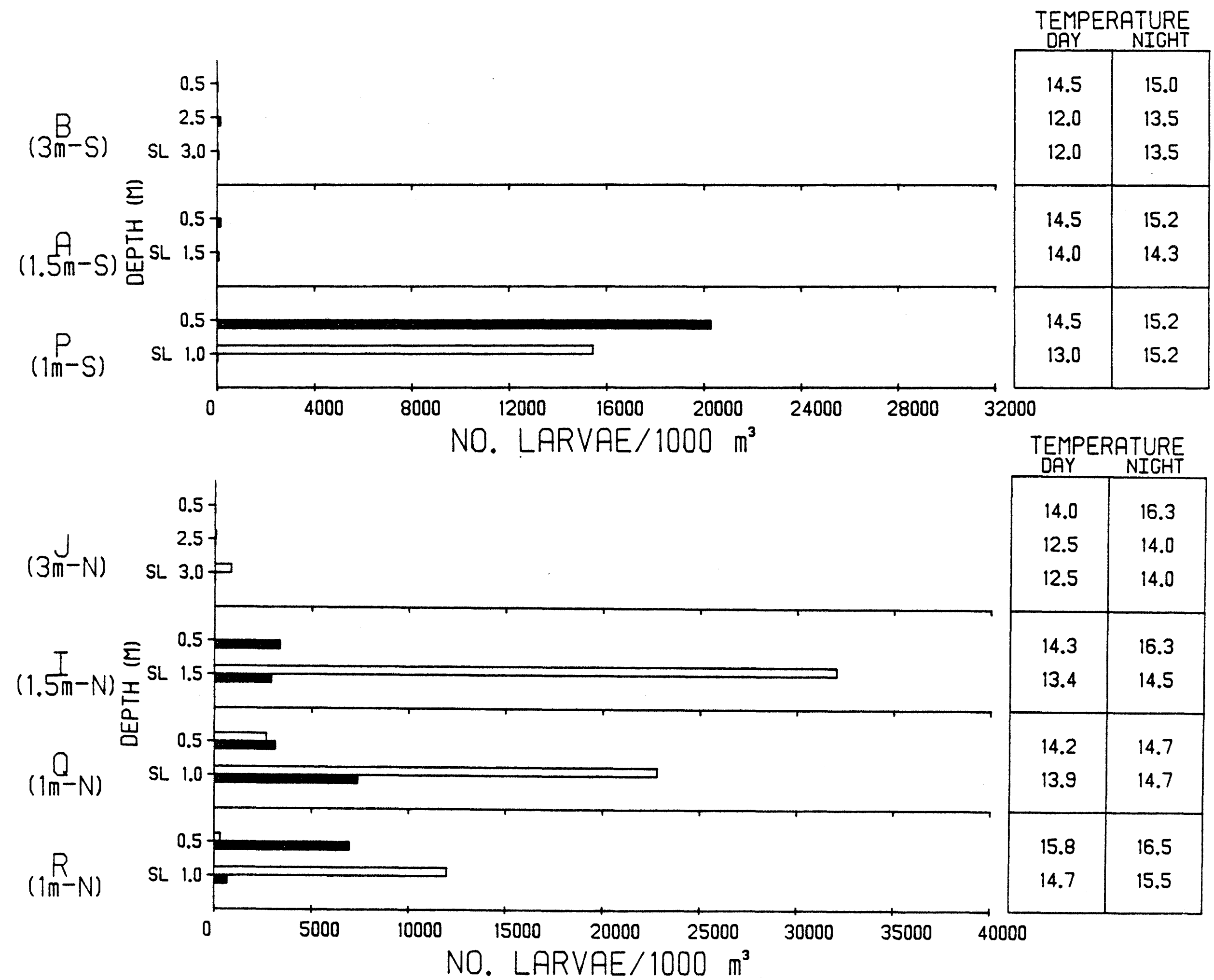


Fig. 93. Density of larval spottail shiners (no./1000 m^3) at Lake Michigan stations near the J.H. Campbell Plant, eastern Lake Michigan, 1-2 August 1979. Stations exhibiting densities less than 107/1000 m^3 were omitted. □ = day, ■ = night SL = sled.

Examination of length-frequency data from all month periods combined, May-August (Fig. 88), illustrates that it was primarily the smaller, newly hatched spottail larvae which were subject to entrainment. Mean sizes of larvae entrained during these months ranged from 5.1 to 5.6 mm. Such size-specific entrainment loss of this species implies that larger larvae can either avoid the present intake current, or seek habitat away from its influence. As with many species of fish larvae, the stage most immediate to hatching appears the most susceptible to entrainment.

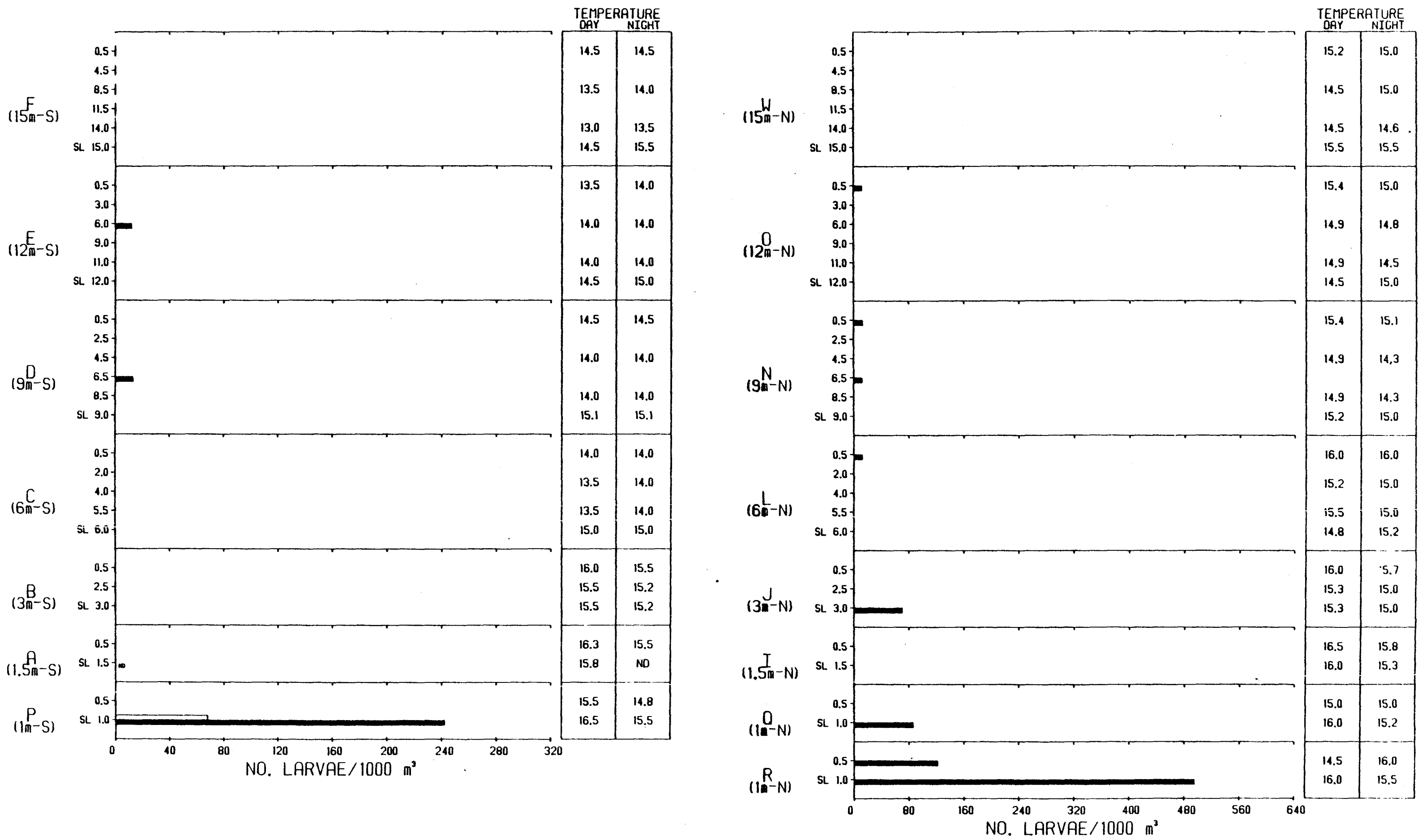


Fig. 94. Density of larval spottail shiners (no./1000 m^3) at Lake Michigan stations near the J. H. Campbell Plant, eastern Lake Michigan, 20-22 August 1979. ☐ = day, ■ = night, SL = sled, ND = no data.

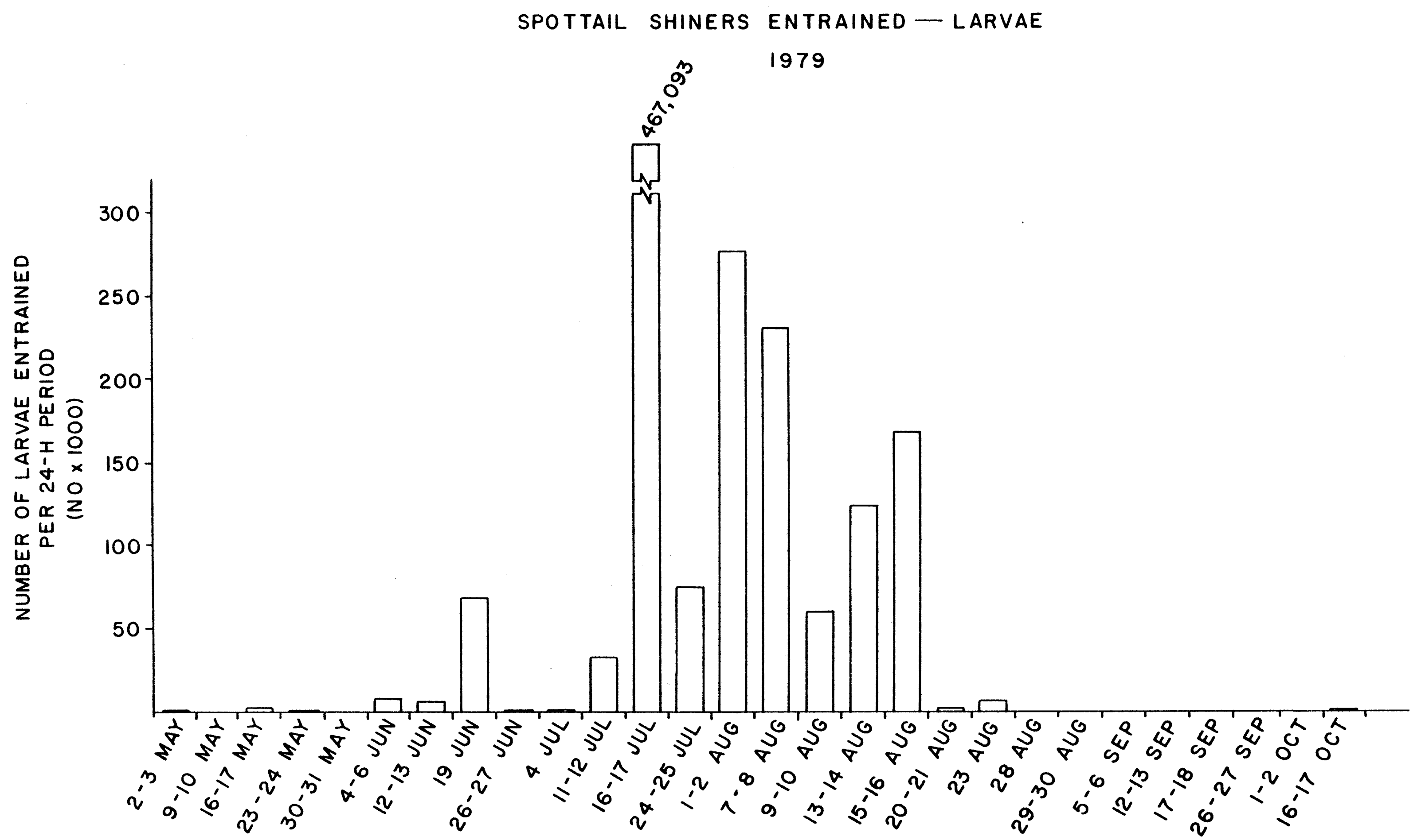


Fig. 95. Total number of larval spottail shiners entrained during a 24-h period projected from densities observed in the 16 samples collected weekly at the J.H. Campbell Plant, eastern Lake Michigan 1979.

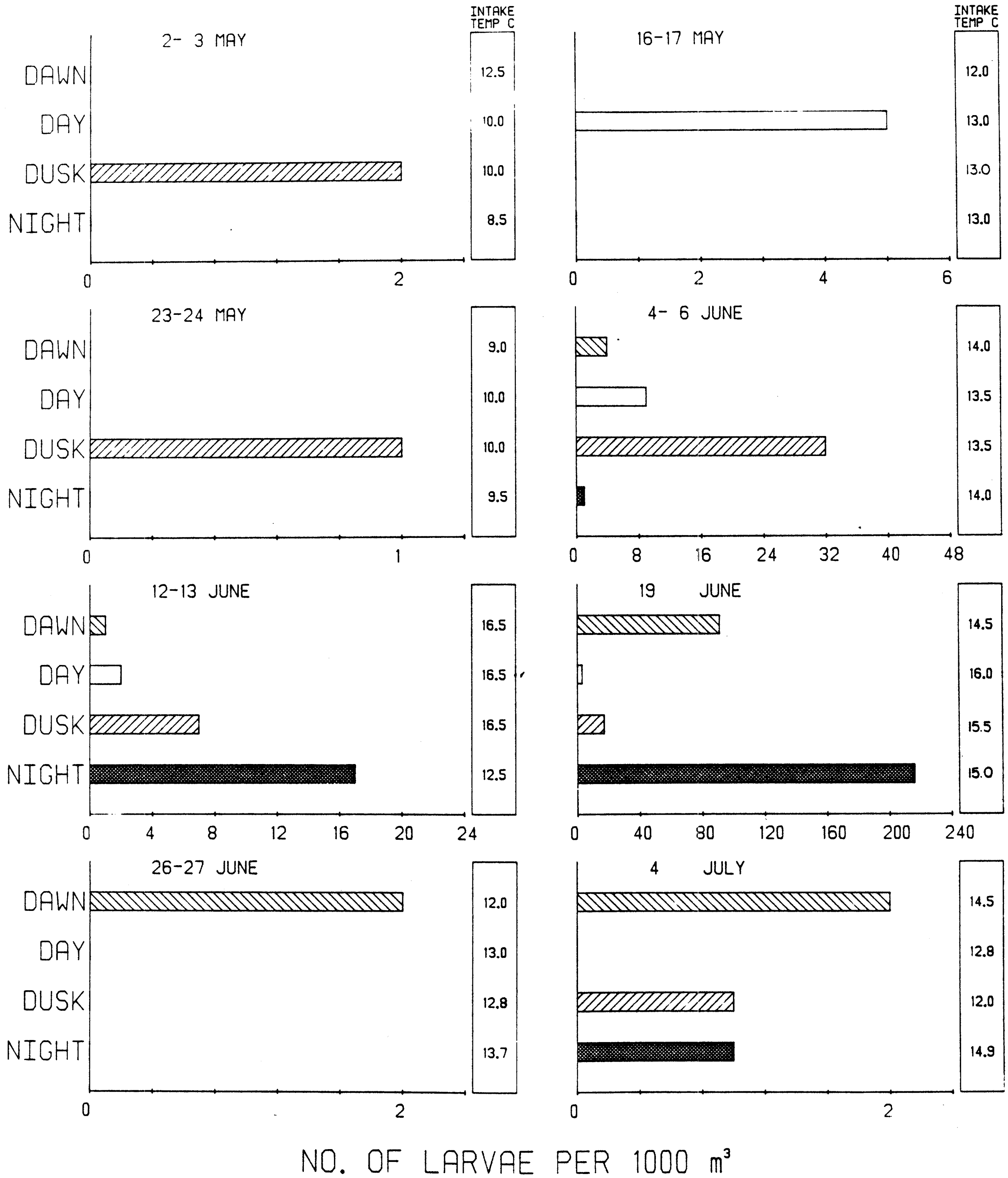


Fig. 96. Density of larval spottail shiners (no./1000 m^3) in weekly dawn, day, dusk and night entrainment samples at the J.H. Campbell Plant, eastern Lake Michigan 1979. ND = no data.

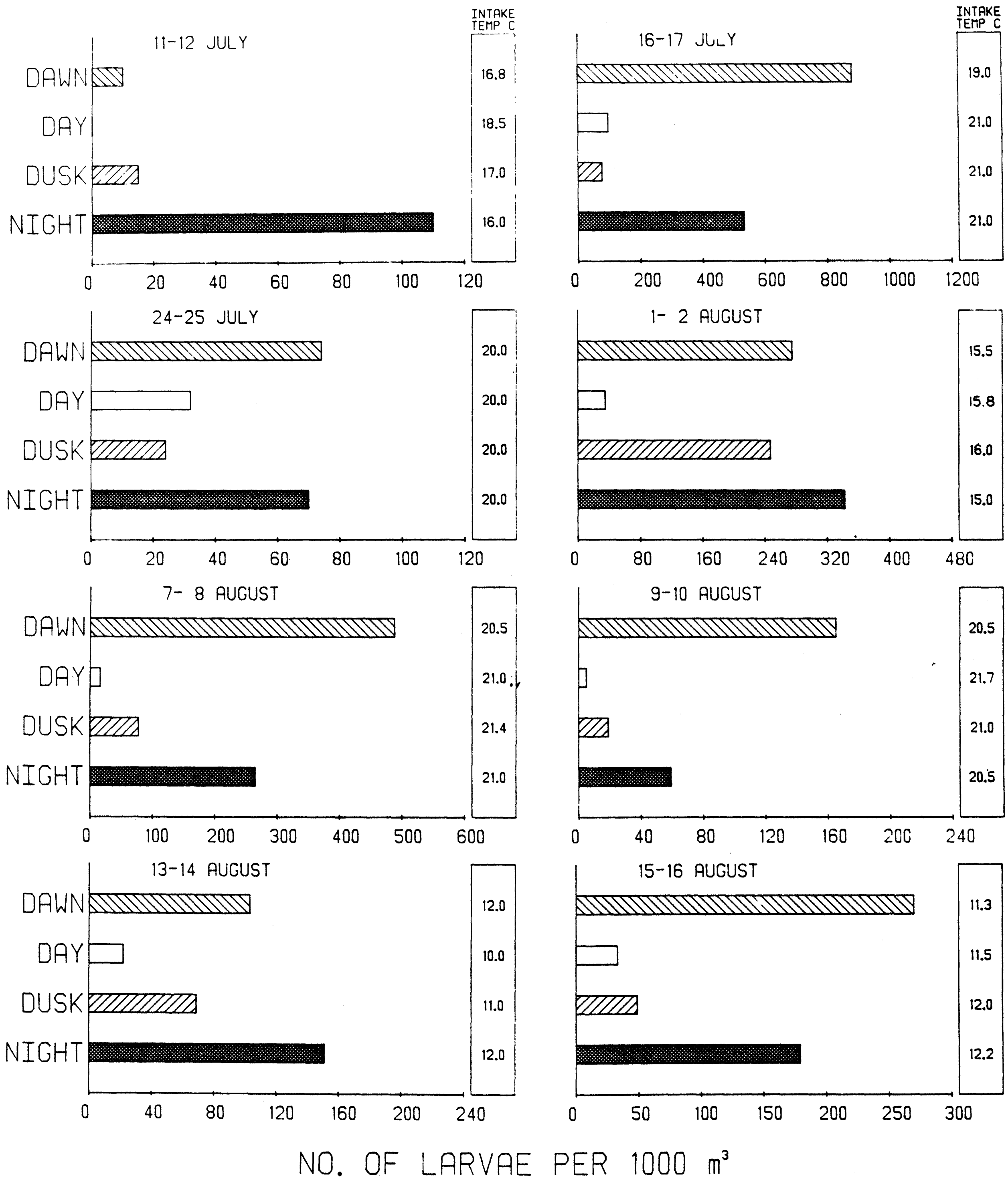


Fig. 96. Continued.

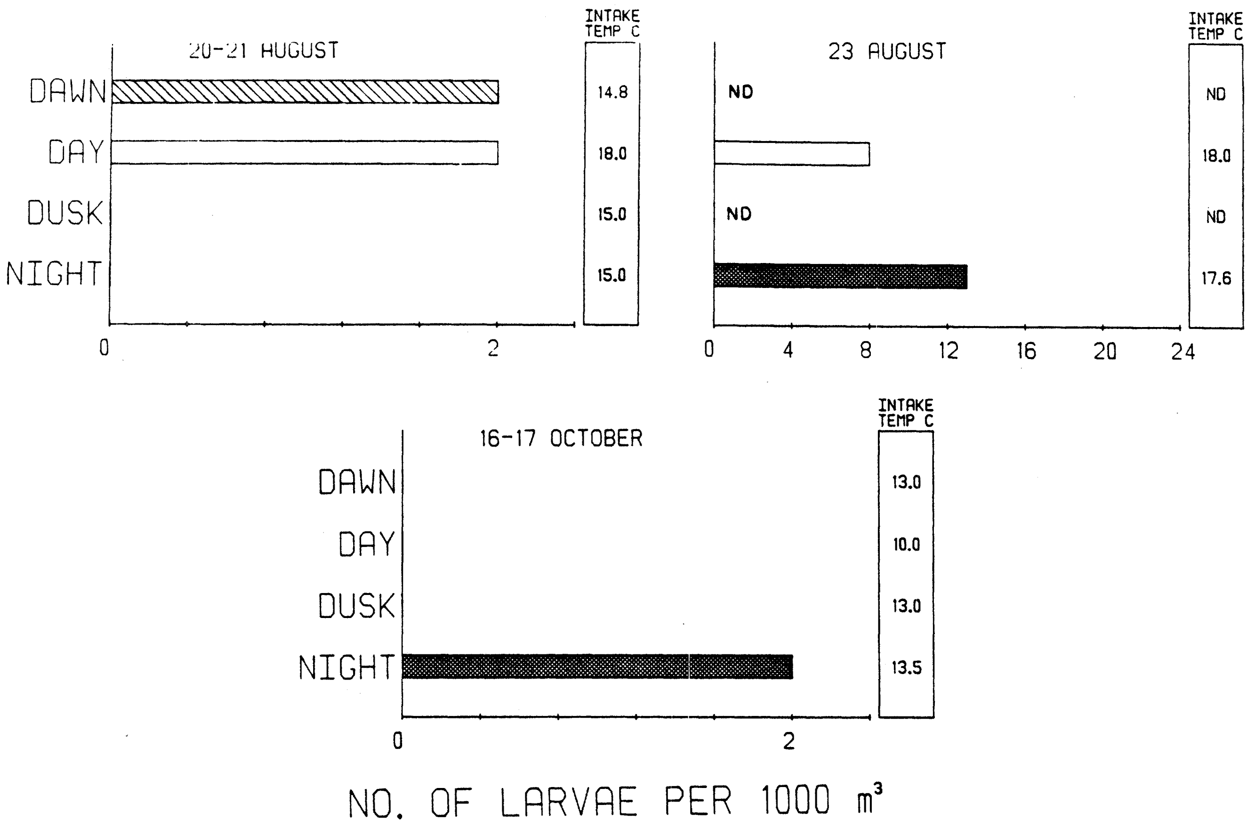


Fig. 96. Continued.

Occurrence of a 17-mm larva in an October entrainment sample, along with the sporadic low occurrence of fry in entrainment samples (Appendix 16) suggests that larger larvae do occasionally move into the intake area and are subsequently entrained.

Emerald shiner--

Distribution of larval and adult emerald shiners in the area of the Campbell Plant has exhibited considerable variation from year to year. We feel that the areas in Pigeon Lake that are influenced by Lake Michigan offer a suitable habitat for propagation of this species; however, pronounced differences observed in the adult catch could not be explained.

During 1977 and 1978 the distribution of emerald shiner larvae was masked in part by problems with distinguishing the larvae from other cyprinids. The general statements made by Jude et al. (1979a) suggesting periodic abundance of emerald shiner larvae at station S (influenced by Lake Michigan) during 1978 are supported by 1979 data. Densities of larval emerald shiners as high as 590 larvae/1000 m³ have been observed at this station

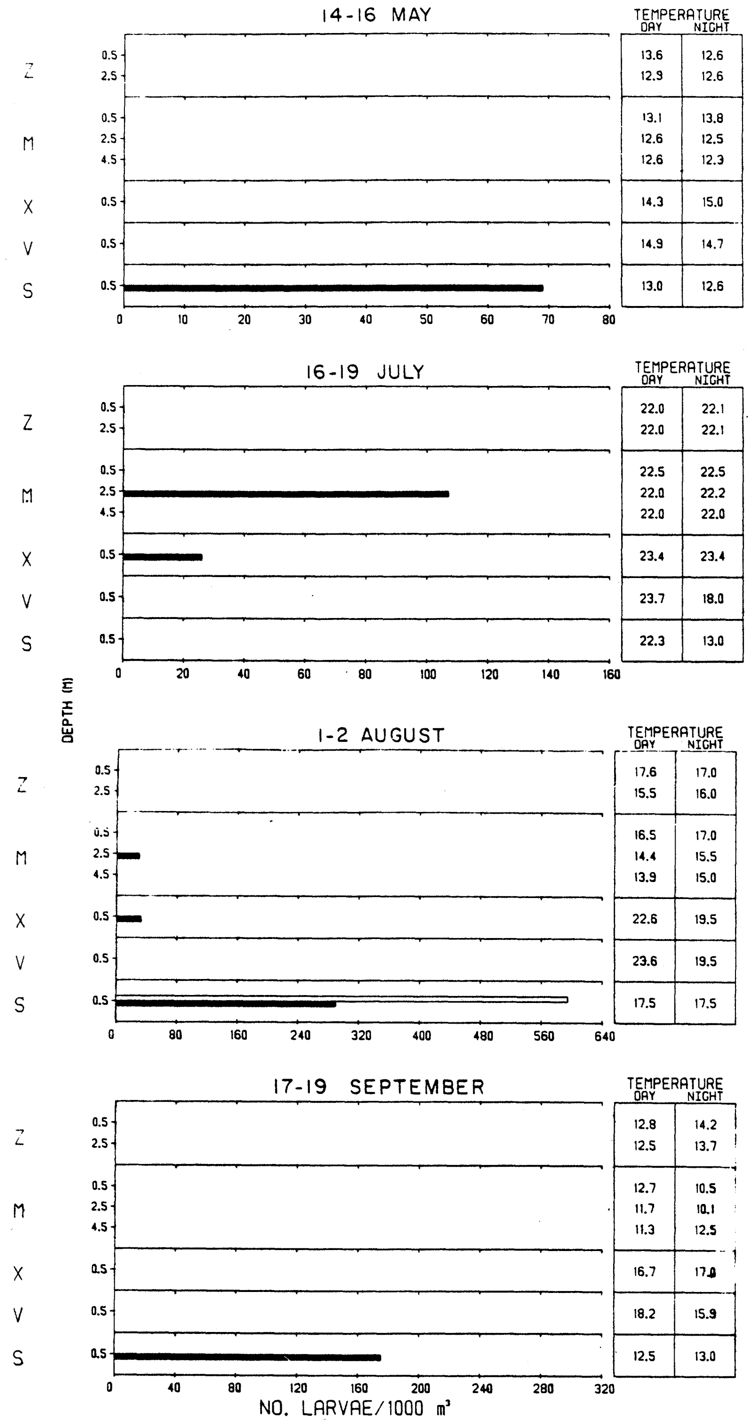


Fig. 97. Density of larval emerald shiners (no./1000 m^3) at Pigeon Lake and intake canal stations near the J.H. Campbell Plant, eastern Lake Michigan, May to September 1979. Stations Z(intake canal), M(6 m, openwater), X(1 m, openwater), V(beach, undisturbed) and S(beach, Lake Michigan influenced) are shown. □ = day, ■ = night.

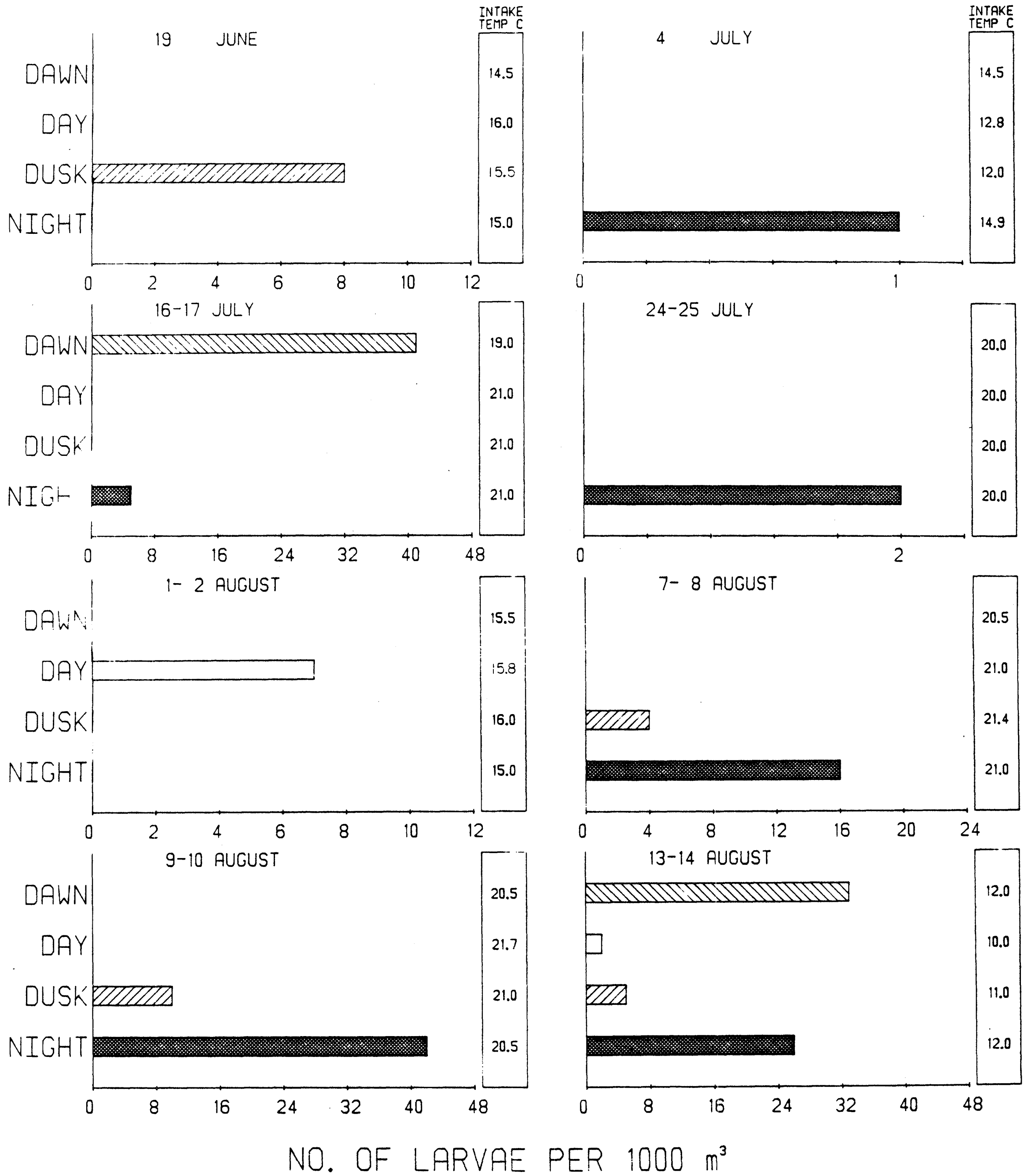


Fig. 98. Density of larval emerald shiners (no./1000 m^3) in weekly dawn, day, dusk and night entrainment samples at the J.H. Campbell Plant, eastern Lake Michigan 1979.

during May-September (Fig. 97). The reason for their periodic absence from our sampling stations in Pigeon Lake during June and July is not known; however, more of a continuum of their presence is indicated by densities of larvae in entrained water (Fig. 98). The occasional occurrence of larval emerald shiners at station X (undisturbed Pigeon Lake - Fig. 97) indicates that this species may spawn in other areas of Pigeon Lake uninfluenced by Lake Michigan.

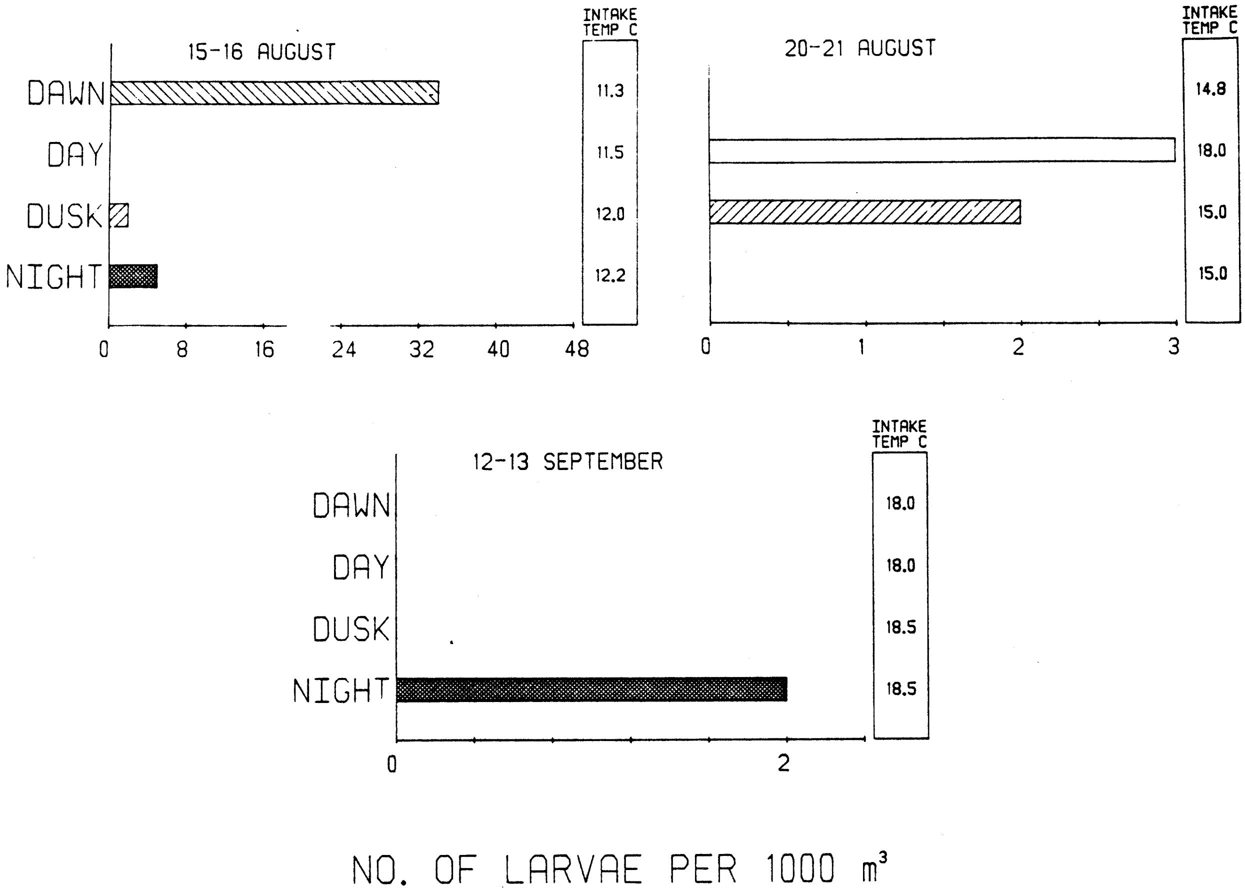


Fig. 98. Continued.

Although once abundant in Lake Michigan, emerald shiners suffered an abrupt decline in abundance after the alewife invasion. Reproduction of emerald shiners in Lake Michigan subsequent to the 1960s has been limited as evidenced by the catastrophic decline in adult catches. Four of the five occurrences of emerald shiner larvae in Lake Michigan were observed in the area of the onshore discharge (Appendixes 10 and 11) indicating the possibility of a population in the discharge canal itself. Distribution of those emerald shiner larvae caught in Lake Michigan, however, exhibited no trend. Densities ranged from 14 to 585/1000 m^3 during June-August.

Entrainment--In general, densities of emerald shiners in entrained water were less than 20 larvae/1000 m^3 with few exceptions (Fig. 98). Entrainment of this species began during 19 June and continued to 12-13 September. Maximum entrainment densities were observed during 17 July (41 larvae/1000 m^3), 10 August (42 larvae/1000 m^3) and 13 August (26 larvae/1000 m^3). August sampling dates coincided with maximum densities of emerald shiners observed in field samples.

Effect of entrainment is difficult to assess due to lack of information on importance of adults in the area. It is probable that removal of such low densities of larval emerald shiners does not appreciably affect the forage base of either the Lake Michigan or Pigeon Lake system. The ramifications of a species shift due to entrainment affecting one species more than another, however, may be more appreciable.

Bluntnose minnow--

Although bluntnose minnows are a common inhabitant of Pigeon Lake, larvae were rarely encountered. Larvae were only observed twice in field collections of April-December 1979. It is assumed that the larvae of this species is demersal and not as susceptible to our gear as some of the other cyprinids. Additional sampling during 1979 indicated that larval bluntnose minnows also appeared to prefer weedy habitat in water less than 3 m. This habitat is not sampled adequately by our standard gear.

A density of over 1300 larvae/1000 m^3 was observed at beach station V (undisturbed Pigeon Lake) in July substantiating the claim that bluntnose minnows do spawn in this habitat. These larvae were small ($\bar{x}$ = 6.6 mm, SE = 0.4) and probably were hatched in early July. Larger larvae ($\bar{x}$ = 15.2 mm, SE = 2.7) were caught at station S (influenced by Lake Michigan) in September resulting in a density of over 1000 larvae/1000 m^3, suggesting that spawning at this station had also occurred; however, lack of larval growth data precludes an estimate of when hatching transpired.

Due to the habit of this species to spawn in slow-moving water in protected areas, it would be expected that the entrainment loss would be minimal. Bluntnose minnow larvae occurred in only four entrainment samples throughout the year. Densities of bluntnose minnow larvae in entrained water during June and July did not exceed 5 larvae/1000 m^3 (Appendix 14).

Golden shiner--

Only one golden shiner larva (5.8 mm) was found in the study area during 1979. It was found at station X (undisturbed Pigeon Lake) at a water temperature of 15.0 C during 16 May sampling. Observations during June 1979 in the more riverine habitats outside our study area indicated that larvae of this species are found most commonly near emergent vegetation (*Scirpus* spp.) in small aggregations (15-30 individuals). They were observed frequently near beach station T, an area influenced by Pigeon River and not

sampled in 1978-1979. It is likely that their spawning areas are also near this station. Small size of the one larva found (5.8 mm) suggests that spawning of golden shiners occurred in late April-early May during 1979.

Carp--

Introduction--Observations in the discharge and intake canals along with sightings of carp during electrofishing efforts in Pigeon Lake indicate that although this species was not sampled extensively by our standard gear during 1977-1979, adult carp are abundant in the area of the Campbell Plant. Extensive carp spawning during May-June 1979 probably occurred in the intake canal, where numerous aggregations of carp have periodically been observed.

In Pigeon Lake larval carp sampling indicated that preferred spawning sites are heavily vegetated, shallow areas similar to those found at station T (influenced by Pigeon River), an area deleted from our sampling during 1978-1979, and station V (undisturbed Pigeon Lake). Larval carp were also caught in a larval seine fished in heavily weeded areas on the south side of Pigeon Lake.

Seasonal Distribution--

May--The first occurrence of carp larvae in 1979 was during May (Fig. 99). Carp spawning in Pigeon Lake was indicated by low (less than 45 larvae/1000 m^3) densities of larvae at stations X (undisturbed Pigeon Lake) and Z (intake canal). Entrainment sampling on 16-17 May (Fig. 100) was nearly coincident with our 15-16 May (Fig. 99) field sampling. Nighttime larval carp entrainment densities were eight times those observed at station Z (intake canal). This observation strongly suggests that origin of the majority of entrained carp was between these two stations (along the length of the intake canal). This is substantiated by our numerous observations of spawning aggregations of carp at locations midway between these stations as well as supplemental sampling during May 1979 which showed carp eggs and larvae among shoreline vegetation.

Coincident with first occurrence of larval carp in Pigeon Lake in May, was their first incidence at Lake Michigan stations. Larval carp were noticeably more abundant at beach station Q (south discharge) than other stations (Fig. 101). This increased abundance at the beach station may be the result of spawning activity in the onshore discharge canal of the Campbell Plant. Some larvae hatched in the canal probably wash out into Lake Michigan, accounting for higher densities at stations near the discharge. The comparably lower densities of larval carp at south transect stations in May may indicate limited spawning in Lake Michigan near the Campbell Plant; however, we believe that these larvae may have also been washed out of Pigeon Lake or the discharge canal. This contention is substantiated in part by the observation at Lake Michigan stations of larvae of species typically not found in Lake Michigan. Specifically, spawning of crappies in Lake Michigan can be negated with much higher reliability than spawning by carp, yet crappie larvae were also found at south transect stations in low densities (see Pomoxis

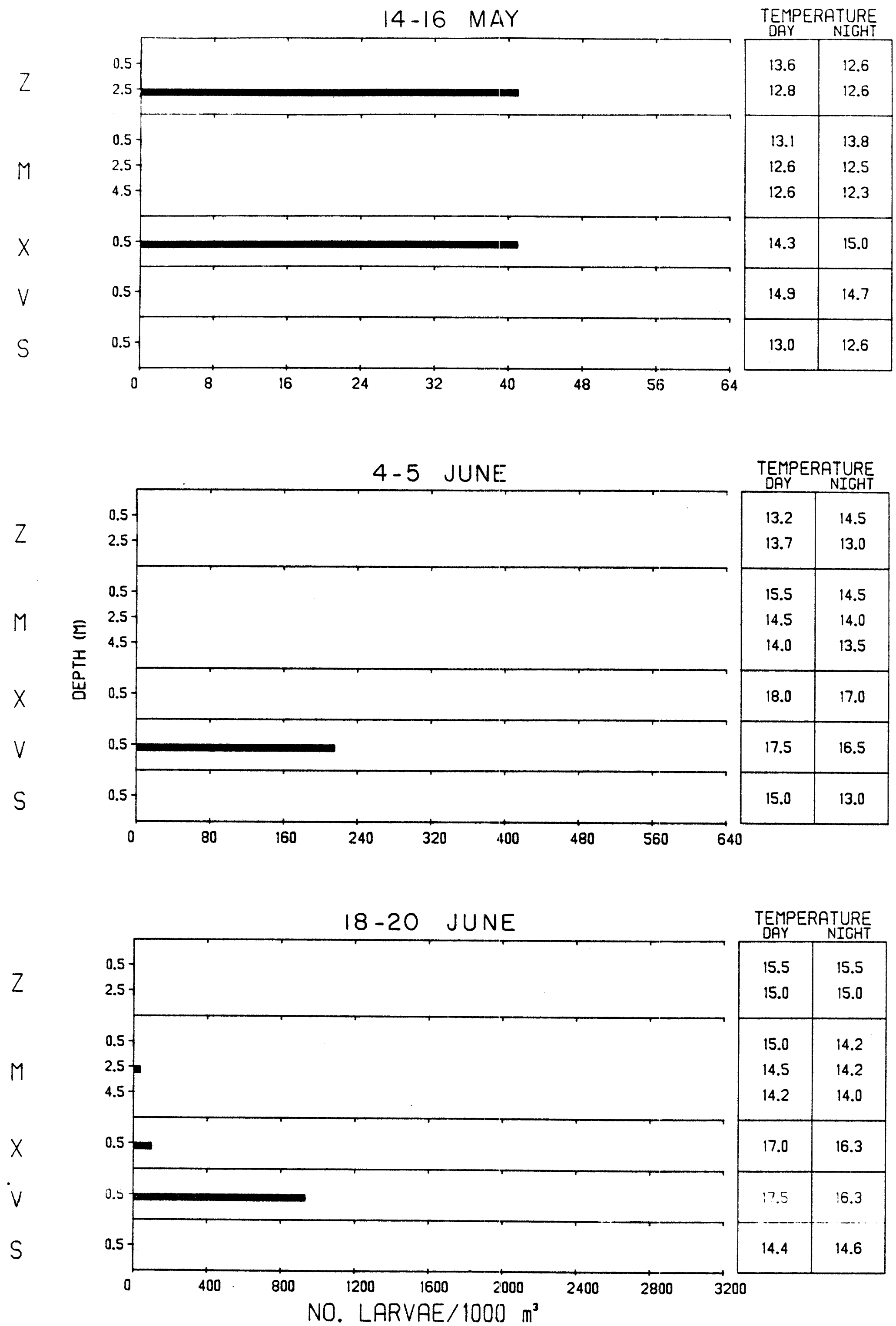


Fig. 99. Densities of larval carp (no./1000 m^3) at Pigeon Lake and intake canal stations near the J.H. Campbell Plant, eastern Lake Michigan, April to September 1979. Stations Z(intake canal), M(6 m, openwater), X(1 m, openwater), V(beach, undisturbed) and S(beach, Lake Michigan influenced) are shown. □ = day, ■ = night.

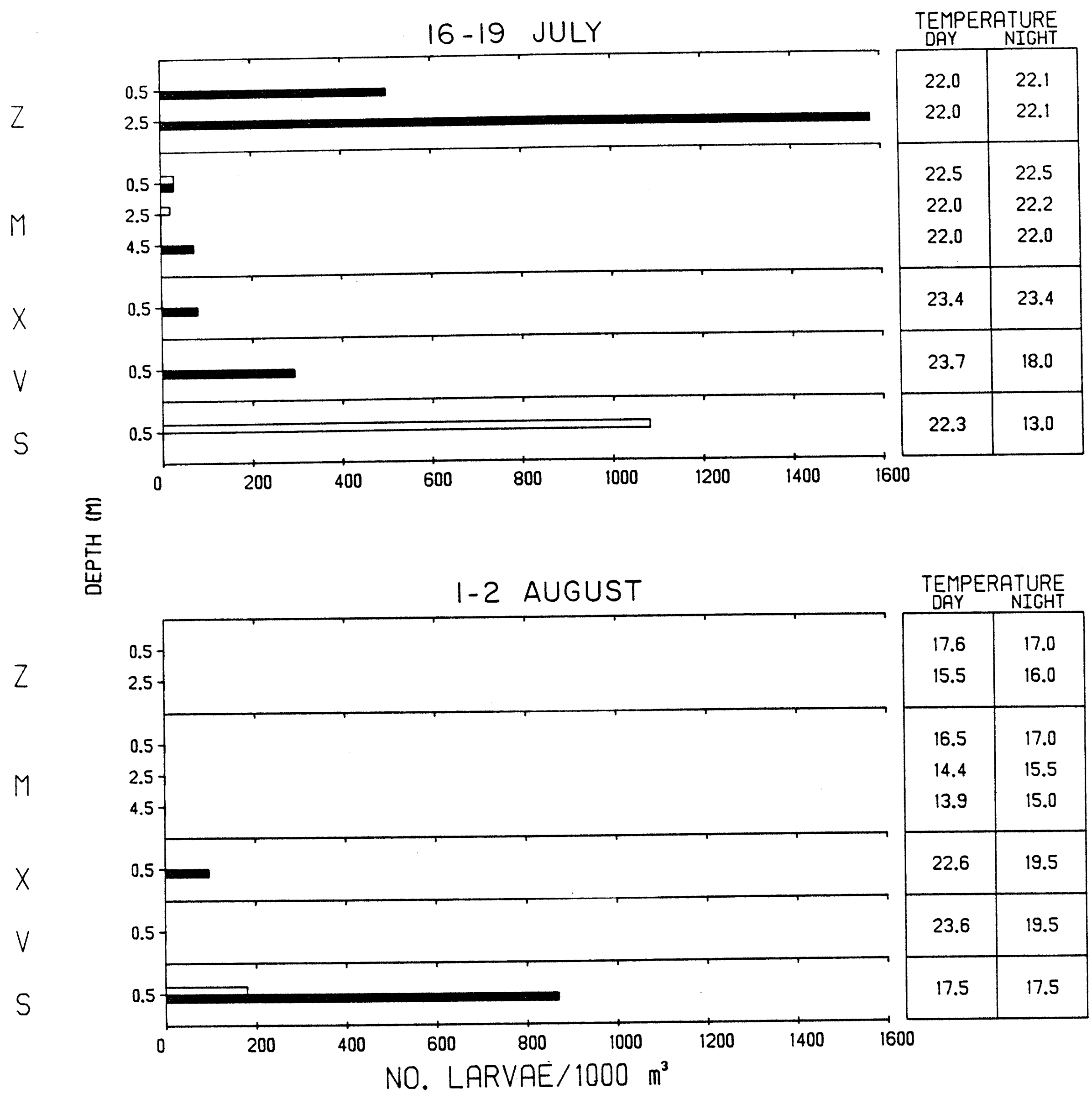


Fig. 99. Continued.

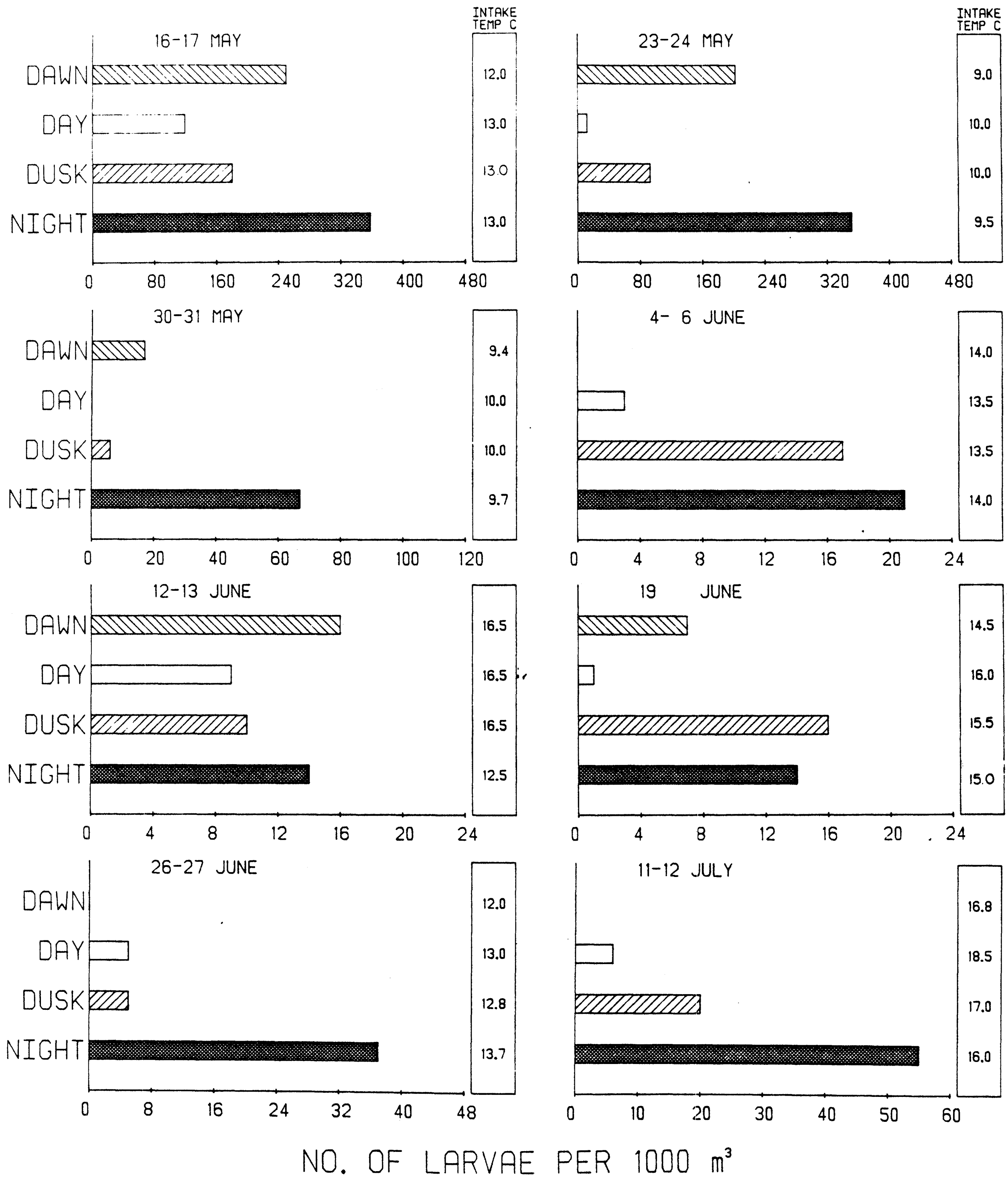
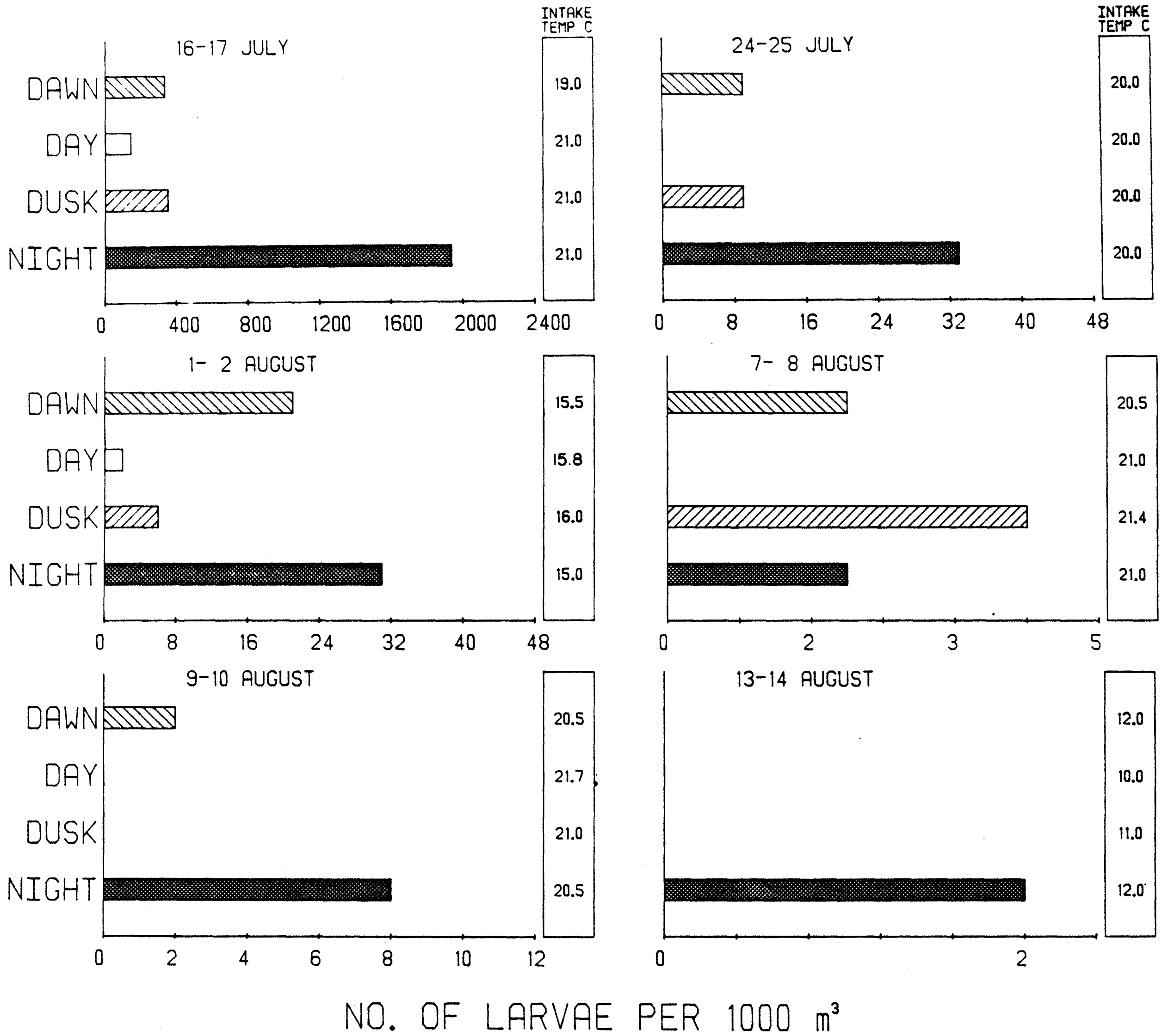


Fig. 100. Density of larval carp (no./1000 m^3) in weekly dawn, day, dusk and night entrainment samples at the J.H. Campbell Plant, eastern Lake Michigan, 1979.



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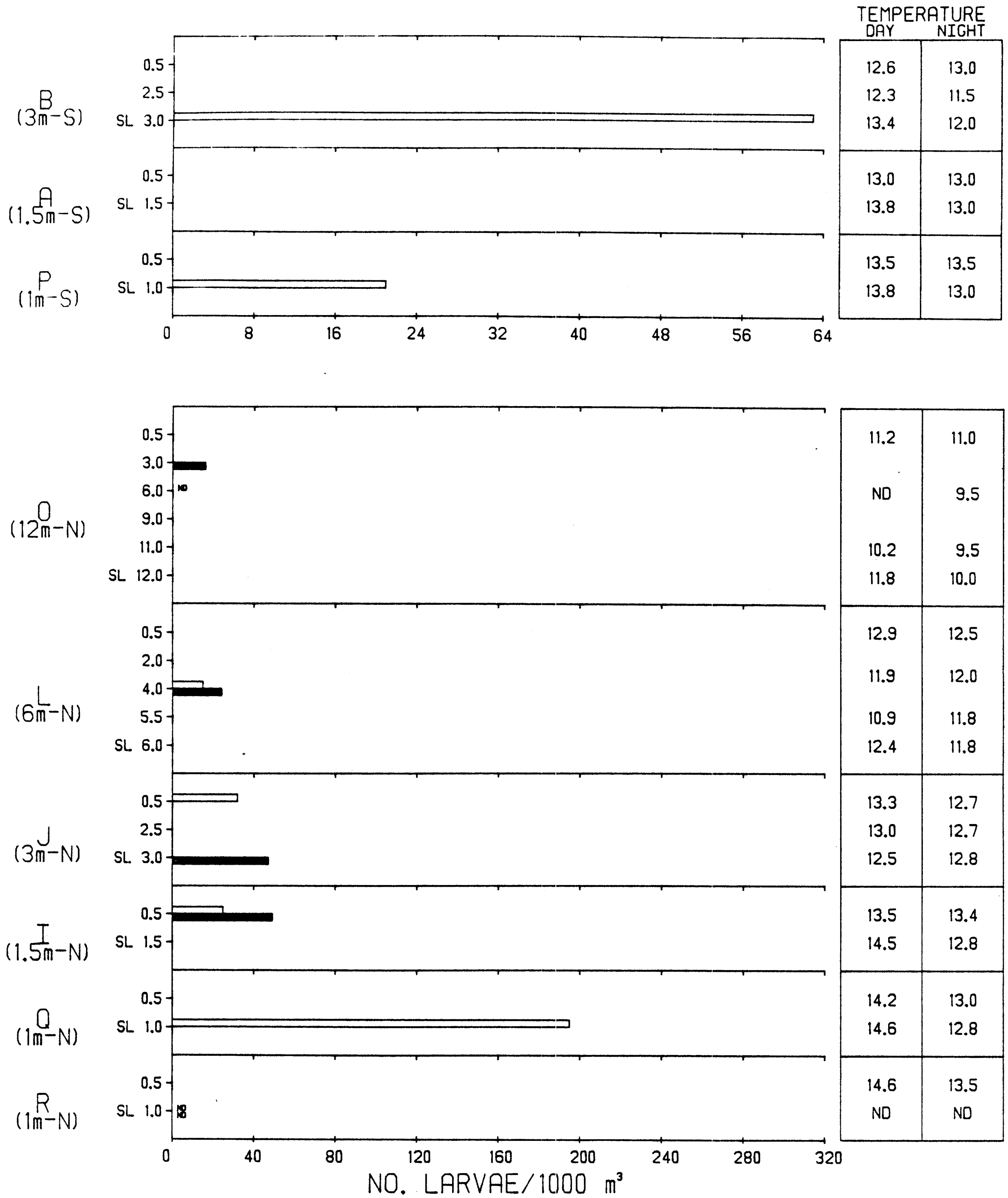


Fig. 101. Density of larval carp (no./1000 m^3) at Lake Michigan stations near the J.H. Campbell Plant, eastern Lake Michigan, 14-16 May 1979. Stations 9 and 15 m north and 6-15 m south were omitted due to absence of larvae from samples. ☐ = day, ■ = night, SL = sled, ND = no data.

spp.). It is thus probable that species which spawn in connecting waters of Lake Michigan are sometimes washed into the lake proper, and show diminishing densities at locations removed from their sources.

Carp were only observed at Lake Michigan stations during one additional sampling period. During 1-2 August, two larvae (3.8 and 6.5 mm) were caught in sled tows at north transect stations I (1.5 m, north) and J (3 m, north) resulting in densities of 296 and 277 larvae/1000 m^3 respectively. These larvae were probably newly hatched, again possibly washing out of the discharge canal.

Sampling in Pigeon Lake during June showed highest densities of carp larvae were at stations V and X (undisturbed Pigeon Lake - Fig. 99). Undoubtedly, this shallow, weedy habitat was highly conducive to carp spawning during June. In spite of high densities of larval carp at station V during both sampling periods in June, concomitant sampling at station Z showed no larvae present. These data suggest that carp larvae spawned in the weedy protected area near station V (undisturbed Pigeon Lake) were not subject to extensive entrainment loss. Densities of larval carp in entrainment samples during June were generally less than 40 larvae/1000 m^3. Again, those entrained during June may be coming predominately from intake canal spawning.

Early July sampling showed an absence of larval carp from all field and entrainment samples. The reason for their absence at this time is unknown. It is apparently not related to water temperature, however, as larval carp were abundant at similar lower temperatures in May and June.

Late July and early August sampling in Pigeon Lake indicated larval carp were abundant at beach station S (influenced by Lake Michigan). In addition, larval densities at station Z (intake canal) in late July exceeded 1500 larvae/1000 m^3. The high densities of larvae at these stations suggest that hatching had occurred at Lake Michigan influenced stations.

The extraordinarily high density of carp larvae noted at station Z on 16 July (Fig. 99) coincided with a similar high density of carp larvae in entrainment samples (Fig. 100) suggesting that larvae entrained in mid-July were probably being drawn from Pigeon Lake. This differs from previous high entrainment densities (16-17 and 23-24 May) when the intake canal was implicated as the source. Carp larvae were not collected in field samples during late August and September, probably due to cessation of spawning and growth of larvae to sizes not susceptible to our gear.

<u>Entrainment</u>--Larval carp experienced one of the most radical increases in entrainment loss of any species between 1978 when an estimated 1.5 million larvae were entrained and 1979 when it was estimated that over 11.2 million were entrained (see YEARLY ENTRAINMENT SUMMARY). The first major entrainment peak was observed on 16-17 May when an estimated 203,672 carp larvae were entrained in that 24-h period (Fig. 102). Such high entrainment losses during this period and the 23-24 May period (Fig. 102) were primarily due to carp spawning in the intake canal itself. The extensive spawning effort observed

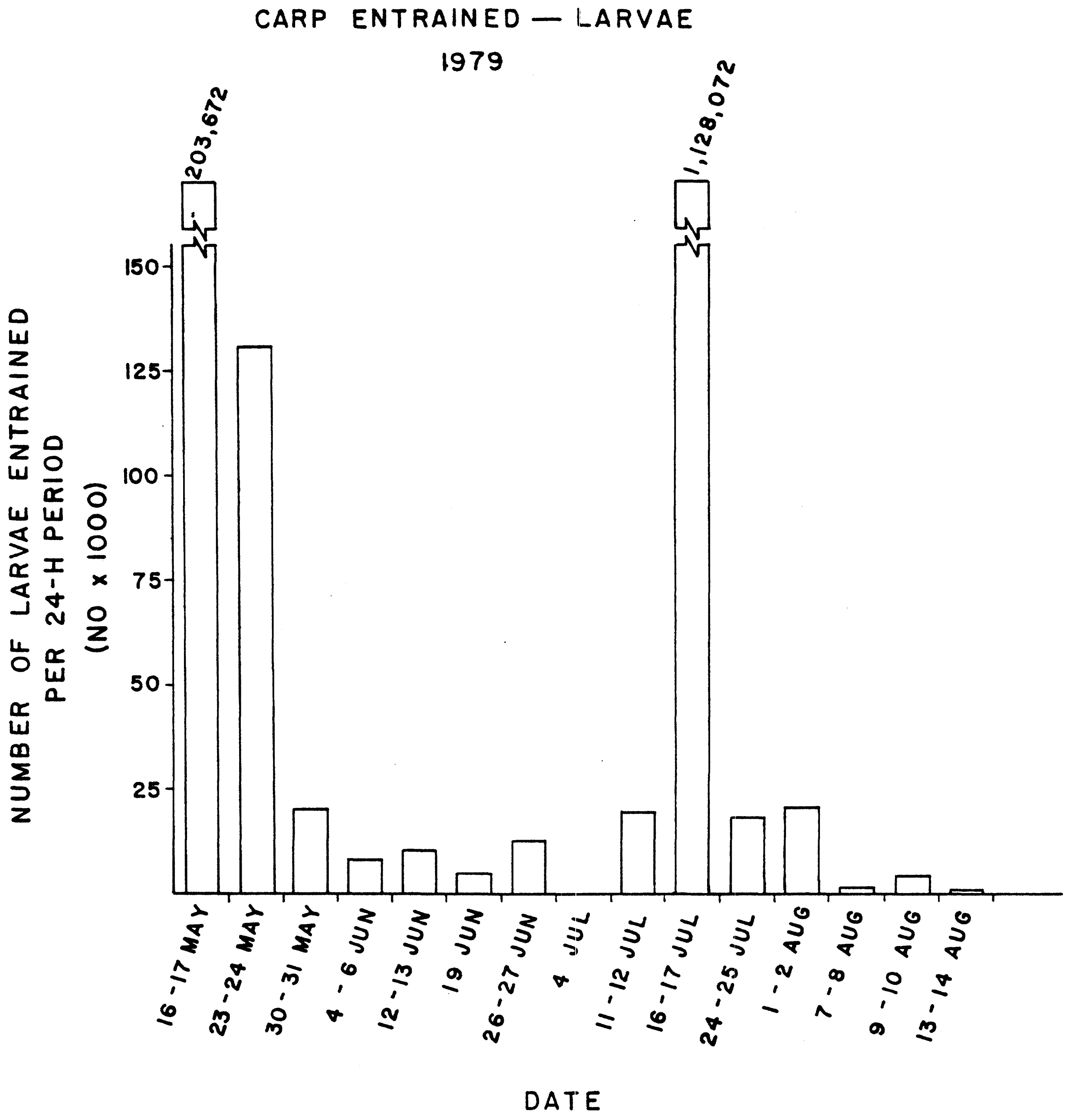


Fig. 102. Total number of larval carp entrained during a 24-h period projected from densities observed in the 16 samples collected weekly at the J.H. Campbell Plant, eastern Lake Michigan 1979.

in the intake canal during 1979 was not evident from May 1978 data. It was observed, however, that just prior to the hatching peak of carp larvae in the intake canal during 1979, the Campbell Plant was not drawing any water. It is thus possible that the temporary halt in plant flow either attracted more carp to spawn there, or increased the success of those eggs spawned there in May 1979 compared with 1978.

Carp entrainment declined significantly during June to mid-July, as densities in entrained water were generally less than 40 larvae/1000 m^3. An increased density of larvae in entrained water on 16-17 July was paralleled by density increases in field samples. An estimated entrainment loss of over 1.1 million carp larvae/24 h period was recorded. This was the greatest entrainment loss/24 h period reported for any species in 1979. This value decreased dramatically during the 24-25 July sampling date when an estimated 18,600 carp larvae/24 h were entrained. Carp entrainment remained at this level during our first August sampling trip before declining to less than 5,000 larvae/24 h period for the remaining sampling dates. After 13-14 August, no carp larvae or fry were entrained at the Campbell Plant in 1979.

In summary, maximum entrainment losses of carp larvae in 1979 were in mid-May and mid-July. Mid-May entrainment loss was related to extensive carp spawning in the intake canal; whereas, maximum entrainment in July was probably related to a spawning peak in Pigeon Lake.

Unidentified Cyprinidae--

Due to our increased expertise, the number of larval cyprinids remaining unidentified decreased dramatically in 1979 compared with 1978. The primary reason for this decrease is our ability to distinguish with certainty spottail shiner, bluntnose minnow, emerald shiner and golden shiner, species previously combined to form this classification. There were only seven occurrences (one or more larvae collected) of unidentified cyprinid larvae at Lake Michigan stations during 1979 (Appendixes 10 and 11). It is significant that four of the seven occurrences were in the area of the discharge. Since very little adult fish sampling has been performed in the discharge canal, it is possible that unidentified cyprinids observed near the canal were species not previously collected. Species which have been observed in the area of the Campbell Plant, of which there are little or no published larval descriptions, include the sand shiner, creek chub, fathead minnow, bigmouth shiner, blacknose shiner and longnose dace. The occurrences of unidentified cyprinids in Lake Michigan show no obvious trends, increasing the difficulty of identifying them.

With the diverse Pigeon Lake habitat, it might be expected that unknown cyprinids would be more prominent than what we found. Of the four occurrences of unknown cyprinids in Pigeon Lake (Appendix 12), three were from stations in the undisturbed areas of Pigeon Lake; the remaining occurrence was at 6-m station M (influenced by Lake Michigan). Entrainment samples indicated that densities of unidentified cyprinid larvae in entrained water were generally less than 15 larvae/1000 m^3 with few exceptions (Appendix 14).

Since this classification could possibly contain a number of species previously mentioned, an in-depth discussion of distributional and seasonal trends is of limited value. It is probable that lotic habitats in the vicinity of the Campbell Plant (Pigeon River and discharge canal) contain species either seldom sampled in our study area or not sampled at all. Larvae of these species may wash into our study area and subsequently be sampled. Since their importance to the area is yet to be determined, we can make no statements as to the effects of the entrainment loss.

Centrarchidae Complex

Introduction--

Nine centrarchids including bluegill, pumpkinseed, green sunfish, warmouth, black and white crappie, largemouth and smallmouth bass and rock bass were known to inhabit Pigeon Lake. Largemouth bass and smallmouth bass larvae were found in low numbers in 1978, but were not collected during 1979. Rock bass larvae occurred only in 1977 and in a few supplementary samples collected at beach station T (influenced by Pigeon River) during June 1978. Early stages of other centrarchid larvae were difficult to identify and were classified as *Pomoxis* spp. and *Lepomis* spp.

Unidentified *Pomoxis* spp.--

Seasonal distribution--

May--Black crappie was one of the more common species collected in Pigeon Lake. White crappies were reported to also occur in Pigeon Lake (Consumers Power Company 1975), but have not been collected during 1977-1979. Since white crappies were scarce in Pigeon Lake, most unidentified *Pomoxis* spp. larvae collected in 1979 were probably black crappies.

Black and white crappies were reported to spawn in spring (Carlander 1977). *Pomoxis* larvae were caught in large numbers during late May and early June in 1977 and 1978. In 1979 *Pomoxis* larvae were first collected during 16-17 May. They were caught in night tows at beach station V (undisturbed Pigeon Lake) at a density of 162 larvae/1000 m^3 (Fig. 103). Highest abundance of larvae (1944 larvae/1000 m^3) was observed at night at station X (undisturbed Pigeon Lake). During the day, *Pomoxis* larvae were also collected at this station with a density of 209 larvae/1000 m^3. Since crappies spawn in water 25 cm to 6.1 m (Morgan 1954), spawning of these species may take place at station X which is approximately 2 m deep. Reasons for higher catches of *Pomoxis* larvae at station X than at station V were not known. Water temperatures at sampling time at these two stations were approximately the same (Fig. 103).

At station M (influenced by Lake Michigan) *Pomoxis* larvae occurred at night at the surface and 2.5-m strata with respective densities of 158 and 174 larvae/1000 m^3 (Fig. 103). Larvae were scarce (26-80/1000 m^3) at this station during daylight. Since the bottom around station M was probably too disturbed

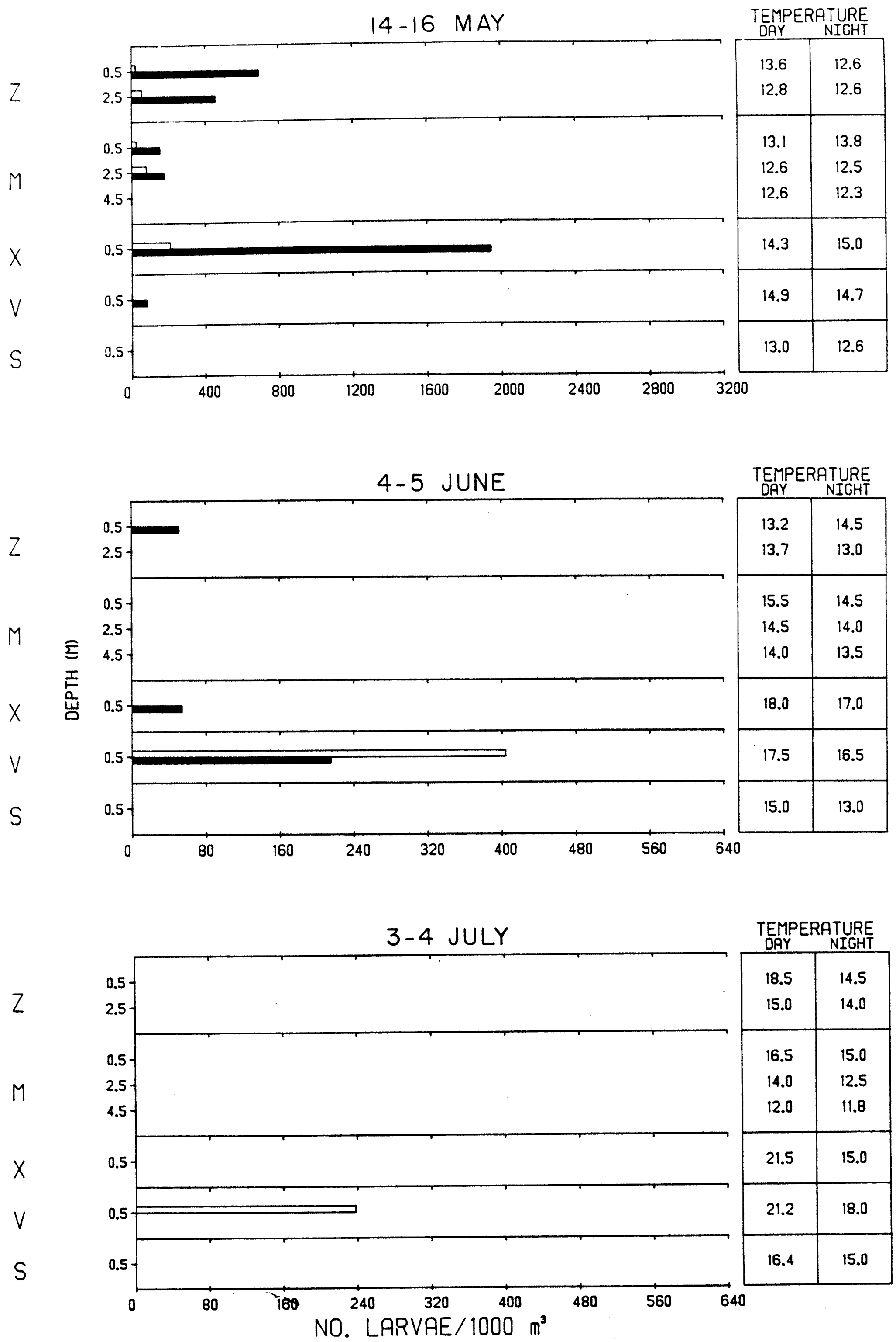


Fig. 103. Density of Pomoxis spp. larvae (no./1000 m^3) at Pigeon Lake and intake canal stations near the J.H. Campbell Plant, eastern Lake Michigan, April to September 1979. Stations Z(intake canal), M(6 m, openwater), X(1 m, openwater), V(beach, undisturbed) and S(beach, Lake Michigan influenced) are shown. □ = day, ■ = night.

(see STUDY AREA) to be utilized by black and white crappies as a spawning ground, *Pomoxis* larvae collected at station M probably originated from other areas of Pigeon Lake.

Pomoxis larvae in appreciable numbers occurred in the intake canal (station Z) during 16-17 May. Night tows at station Z captured *Pomoxis* larvae with densities of 698 larvae/1000 m^3 at the surface and 454 larvae/1000 m^3 near bottom (2.5 m) (Fig. 103); while during the day, densities were 23 and 56 larvae/1000 m^3 respectively. *Pomoxis* larvae collected in the intake canal were probably carried there by currents from Pigeon Lake. Some spawning may also take place in the intake canal (Jude et al. 1979a). No *Pomoxis* larvae were found at beach station S (influenced by Lake Michigan) during 1979. In 1978 *Pomoxis* larvae were first collected in entrainment samples at the end of May suggesting that spawning took place earlier in 1979 than in 1978. Average water temperature at station V (undisturbed Pigeon Lake) at seining time during May 1979 (14.9 C) was slightly higher than during May 1978 (13.7 C).

Minimum hatching lengths of black crappie and white crappie larvae were respectively 2.32 and 2.54 mm (Siefert 1969). White crappies were reported to leave the nests at 4.1-4.6 mm, approximately 4 days after hatching (Siefert 1968). *Pomoxis* larvae we collected appeared to be most vulnerable to plankton net sampling at the above size range. Amundrud et al. (1974) reported catching black crappie larvae of similar size (4-5.5 mm) in plankton nets towed in water up to 3 m deep in Lake Opinicon, Ontario around mid-May. *Pomoxis* larvae less than 3.0 mm have not been collected in the study area during 1977-1979. All *Pomoxis* larvae collected during 16-17 May were 4-5 mm (Fig. 104). Occurrence of *Pomoxis* larvae in this size range at stations M and Z (intake canal) suggested these larvae also became susceptible to being drawn into the current at the time they left the nests. No *Pomoxis* larvae were collected in Pigeon Lake or the intake canal during May 1978 probably as a result of the delay of spawning as previously mentioned.

Low numbers of *Pomoxis* larvae were also caught in Lake Michigan during May. On the north transect, they were found in night sled tows at beach station Q (south discharge) and station J (3 m, north); densities were 49 and 26 larvae/1000 m^3 respectively. *Pomoxis* larvae were also collected during the day at station L (6 m, north) with a density of 21 larvae/1000 m^3 (Appendix 10). On the south transect, *Pomoxis* larvae occurred in night tows at beach station P and at 9-m station D, with respective densities of 149 and 16 larvae/1000 m^3 (Appendix 11). Since black and white crappies probably do not spawn in Lake Michigan near the Campbell Plant, these larvae were probably carried by currents from Pigeon Lake or the discharge canal.

June and July--During June *Pomoxis* larvae populations declined substantially from their May levels. Highest density of *Pomoxis* larvae during 4-5 June (404 larvae/1000 m^3) was observed in day tows at beach station V (undisturbed Pigeon Lake); at night, densities were 215 larvae/1000 m^3 (Fig. 103). Station V was known to be a major spawning ground for crappies (see RESULTS AND DISCUSSION-ADULT AND JUVENILE FISH-Black Crappie). *Pomoxis* larvae were also most abundant at this station during early June 1978. In contrast to May findings, *Pomoxis* larvae were found only in low numbers at

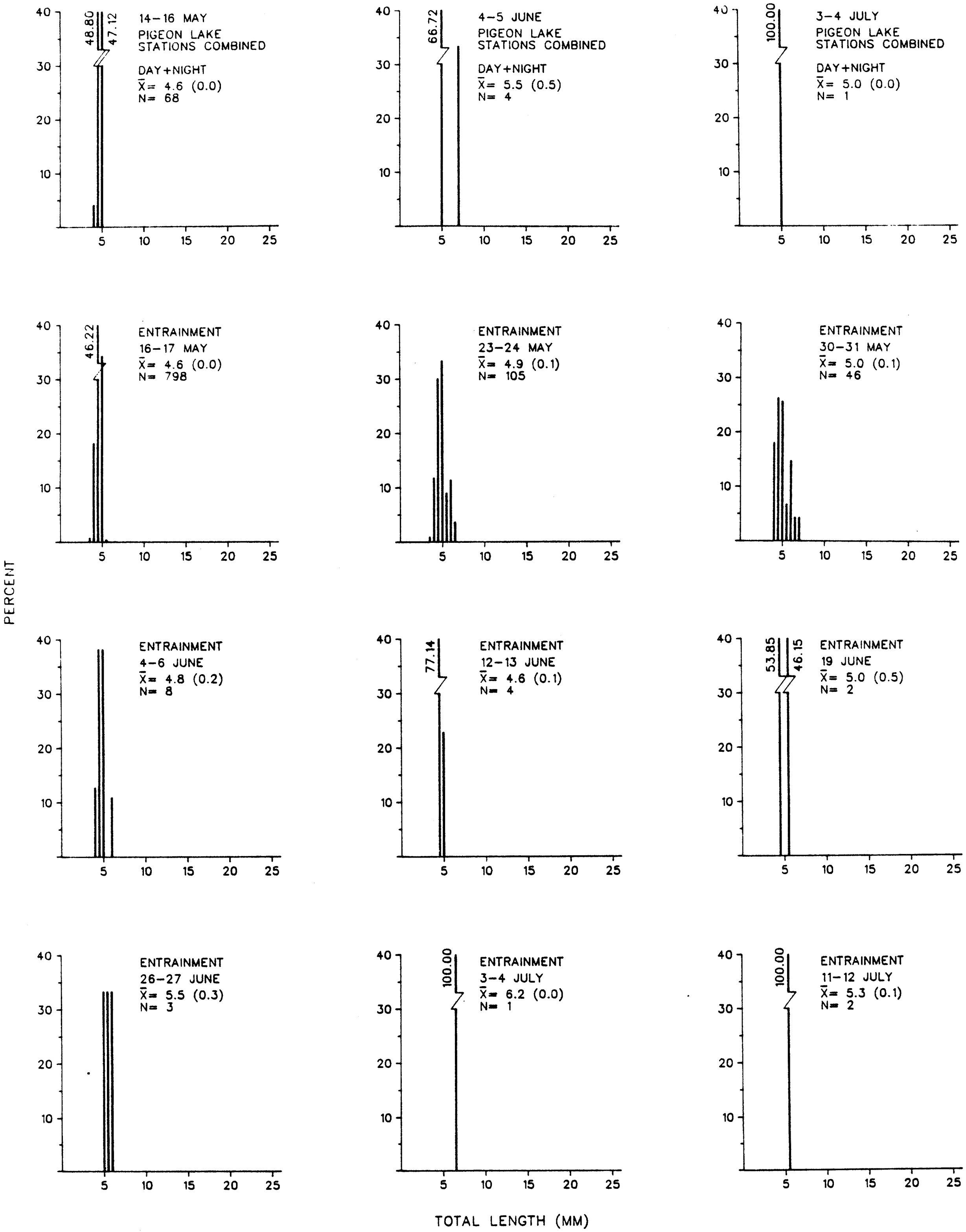


Fig. 104. Length-frequency histograms for Pomoxis spp. larvae observed in field and entrainment samples collected during 1979 near the J.H. Campbell Plant, eastern Lake Michigan. $\overline{X}$ = mean, N = total number of larvae collected, standard error is given in parentheses.

station X (undisturbed Pigeon Lake) during 4-6 June (Fig. 103). They occurred at this station only at night (54 larvae/1000 m^3). Similar densities (60 larvae/1000 m^3) were observed at night at the surface of the intake canal (station Z). No larvae were caught at station M during early June. Low catches of larvae during 4-6 June probably resulted from the decline of hatching of these species in Pigeon Lake during late spring.

Size range of Pomoxis larvae collected during 4-6 June (5-7 mm) increased slightly compared to the 4- to 5-mm range observed during May (Fig. 104). Pomoxis larvae (5 mm) also occurred in Lake Michigan at station F (15 m, south) during early June. These larvae probably came from the discharge canal. None were collected during 18-20 June. Larval Pomoxis were scarce in Pigeon Lake and the intake canal during summer. During 1-2 July Pomoxis larvae were found in low numbers (240 larvae/1000 m^3) in day tows at beach station V (undisturbed Pigeon Lake). These larval species were not collected in Pigeon Lake and the intake canal during the remainder of the year. Pomoxis larvae appeared to be more abundant in 1979 than 1978, probably because of more successful spawning.

Entrainment--

May--Entrainment samples were not taken during 8-11 May due to plant shut down. Pomoxis larvae first occurred in entrainment samples during 16-17 May with a density of 355 larvae/1000 m^3 (518,840 larvae/24 h). This high rate of entrainment, which represented peak entrainment during 1979 (Fig. 105), coincided with the high level of abundance of Pomoxis larvae in Pigeon Lake. It may in part be responsible for the relatively low abundance of YOY black crappies in Pigeon Lake during the summer and fall 1979 (see RESULTS AND DISCUSSION, ADULT AND JUVENILE FISH-Black Crappie). Pomoxis larvae were entrained at a substantially lower density (60 larvae/1000 m^3) during peak entrainment in 1978. In 1978, peak entrainment of Pomoxis larvae did not occur until 1-2 June, confirming our previous observations on the early spawning of black crappie in 1979. Pomoxis larvae entrainment declined rapidly during the last 2 wk of May probably due to low hatching rates in Pigeon Lake. Densities of entrained larvae were 48 larvae/1000 m^3 (67,016 larvae/24 h) during 23-24 May and 20 larvae/1000 m^3 (18,615 larvae/24 h) during 30-31 May (Fig. 105, Appendix 14).

Entrained Pomoxis larvae ranged from 3.5 to 6.5 mm during 16-17 May, 3.5 to 6.5 mm during 23-24 May and 4 to 7 mm during 30-31 May (Fig. 104). The majority of larvae entrained during May were 4 to 5 mm. As previously mentioned, Pomoxis larvae in this size range start to leave their nests and may be easily drawn into the current produced by the plant. This larval habit was probably the main cause of high entrainment during May. Larger Pomoxis larvae 5.5-7 mm occurred only in low percentages (Fig. 104) probably because they were able to avoid being carried by current to the intake canal.

June, July and August--Entrainment of Pomoxis larvae remained low throughout June, ranging from 351 to 3607 larvae/24 h (Fig. 105). Larvae collected during this month ranged from 4 to 6.5 mm (Fig. 104). As was found in May, most larvae entrained during June were 4-5 mm. Pomoxis larvae 5-6.5

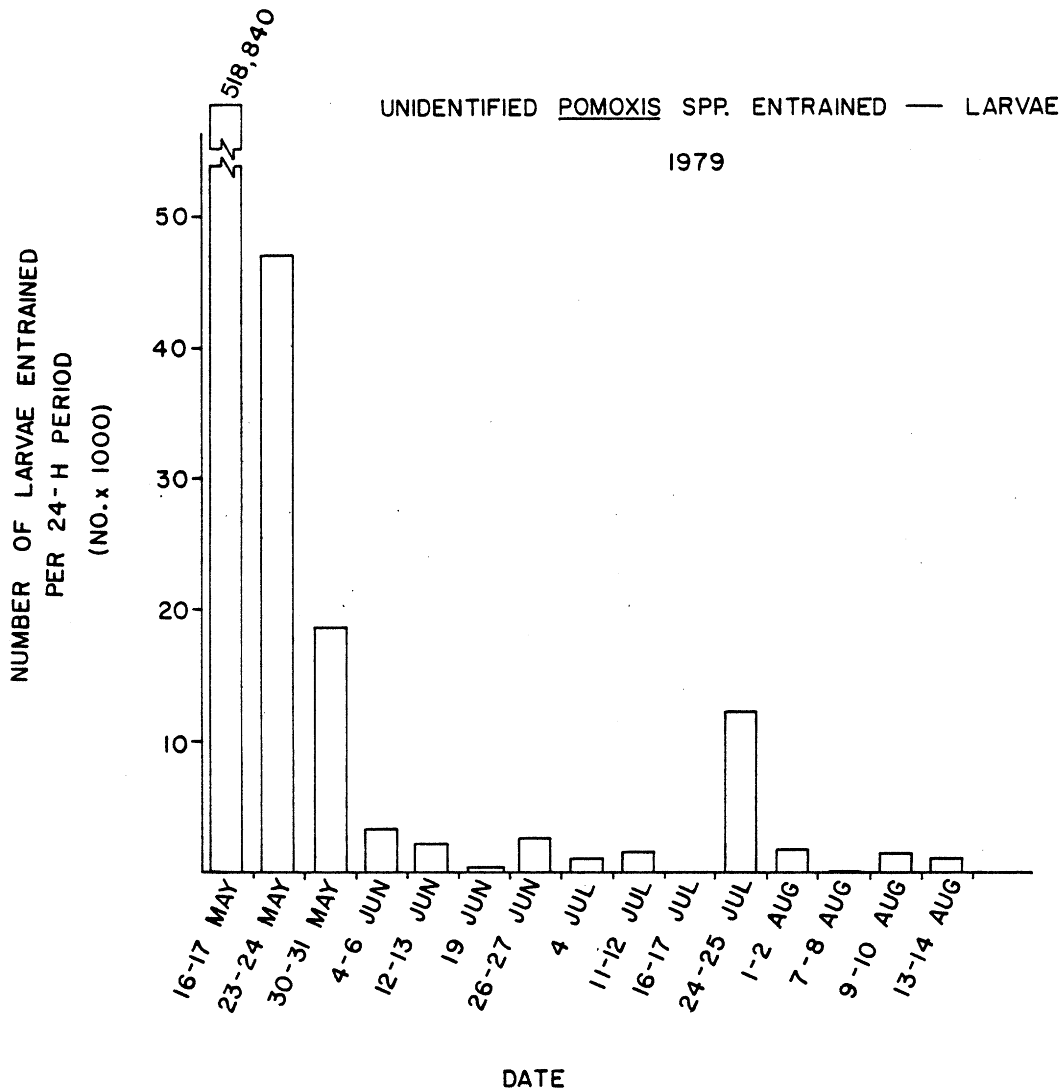


Fig. 105. Total number of Pomoxis spp. larvae entrained during a 24-h period projected from the densities observed in the 16 samples collected weekly at the J. H. Campbell Plant, eastern Lake Michigan 1979.

mm were entrained at rates of 1086 and 1954 larvae/24 h during the first 2 wk of July. They were slightly more common (12,250 larvae/24 h) in entrainment samples collected during 24-25 July. Pomoxis larvae continued to be entrained in low numbers (136-1698 larvae/24 h) during the first 2 wk of August (Appendix 14). In 1978, no Pomoxis larvae were entrained during July, but low numbers of larvae appeared in early August entrainment samples as was observed in 1979. Occurrence of 5-mm larvae in August suggested some black crappie spawning occurred in the study area through late July.

Pomoxis larvae were collected during all diel periods of entrainment sampling (Fig. 106). During peak entrainment (16-17 May), they were found most frequently during the day (Fig. 106). During the same period, more larvae were caught at night than during the day in Pigeon Lake (Fig. 103). Reasons for this discrepancy in diel behavior of *Pomoxis* larvae are not known. *Pomoxis* larvae were collected in higher numbers in field and entrainment samples in 1979 than in 1978.

Unidentified *Lepomis* spp.--

Seasonal distribution--Unidentified *Lepomis* spp. larvae probably included bluegill, pumpkinseed, green sunfish and warmouth larvae. Since bluegill and pumpkinseed dominated the adult sunfish populations in Pigeon Lake (see RESULTS AND DISCUSSION, ADULT AND JUVENILE FISH) most *Lepomis* larvae probably belonged to these two species. Only small numbers of green sunfish and warmouth were collected during 1977-1979 suggesting that larvae of these species were also scarce in the study area.

Sunfish spawn from late May to August (Carlander 1977). Some spawning probably occurred in Pigeon Lake during late April in 1978 (Jude et al. 1979a). In 1979, *Lepomis* larvae first appeared in Pigeon Lake in June. During 4-6 June, a 4.5-mm *Lepomis* larva was collected in day tows at station V (undisturbed Pigeon Lake); larval density was estimated at 202 larvae/1000 m^3. Since hatching length of the four sunfish species inhabiting Pigeon Lake ranged from 2.4 to 3.7 mm (Carr 1939; Taubert 1977; Morgan 1951), this 4.5-mm larva was probably recently hatched. During 18-20 June, *Lepomis* larvae (6.5 mm) were collected during the day at station V; density was 190 larvae/1000 m^3 (Fig. 107). No *Lepomis* larvae were caught at other Pigeon Lake stations or in the intake canal. Scarcity of these larvae suggested that very little sunfish spawning took place during June 1979. Low catches of *Lepomis* larvae were also observed during June 1978.

During 2-3 July, *Lepomis* larvae were caught at station X (undisturbed Pigeon Lake) with a density of 38 larvae/1000 m^3 during the day and 30 larvae/1000 m^3 at night (Fig. 107). Night surface tows at station Z (intake canal) also captured a small number (33 larvae/1000 m^3) of these larval species. *Lepomis* larvae collected during early July were approximately the same size (5-6.5 mm) as those collected during June. *Lepomis* larvae become relatively common in Pigeon Lake during late July due probably to increased sunfish spawning. During 16-19 July, they were caught at night at station V (undisturbed Pigeon Lake) at a density of 2189 larvae/1000 m^3. Small numbers of *Lepomis* larvae (21 larvae/1000 m^3) also occurred at night in intake canal surface waters (station Z). *Lepomis* larvae collected during late July ranged from 4 to 8 mm. Only a small percentage of larvae were 5 mm and smaller (Fig. 108), suggesting that recently hatched larvae were not vulnerable to our sampling gear. *Lepomis* larvae were found only at night; they were not caught during the day probably because of net avoidance during daylight. *Lepomis* larvae collected in the intake canal (station Z) were probably carried by current from Pigeon Lake. July catches of *Lepomis* larvae were higher in 1979 than 1978.

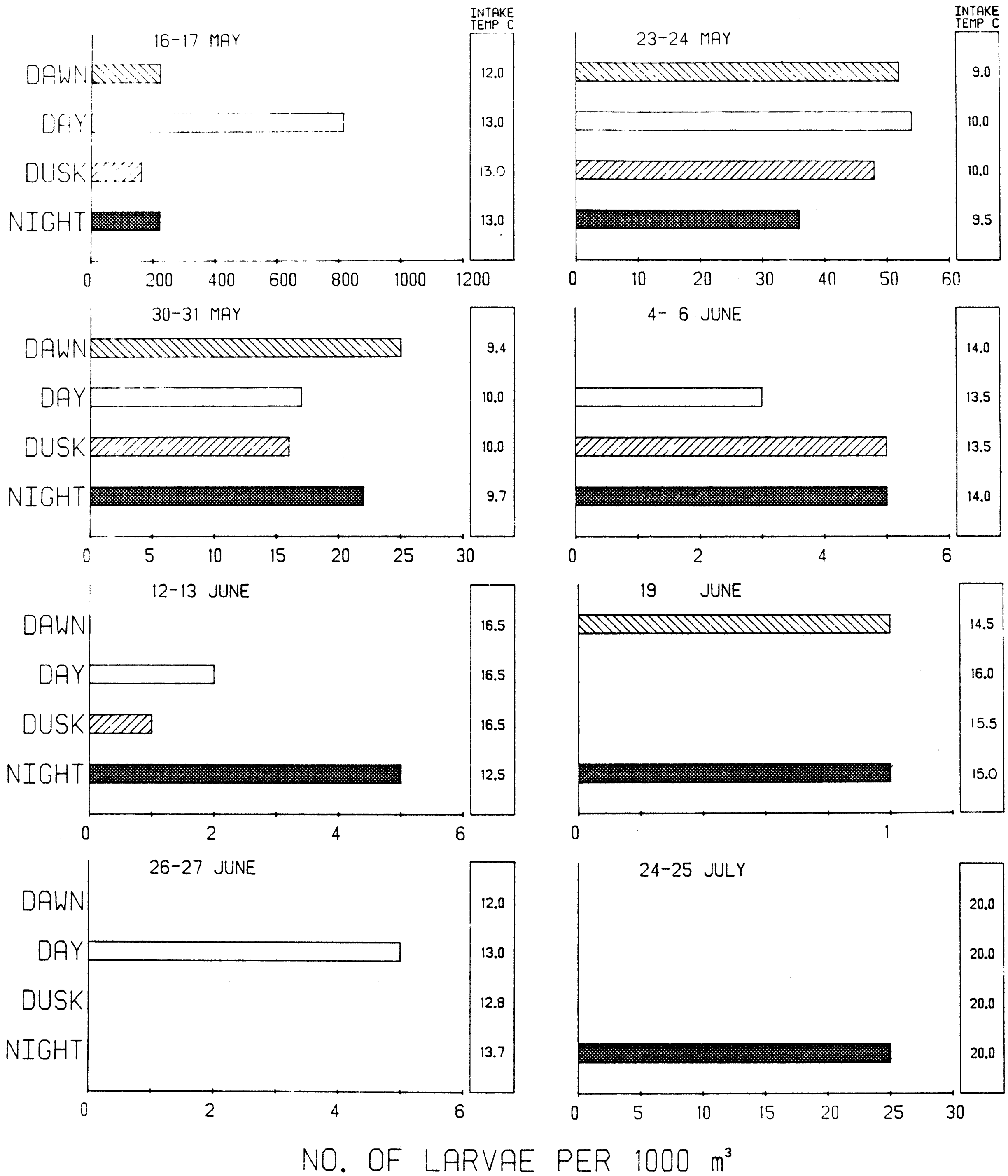


Fig. 106. Density of <u>Pomoxis</u> spp. larvae (no./1000 m^3) in weekly dawn, day, dusk and night entrainment samples at the J.H. Campbell Plant, eastern Lake Michigan 1979.

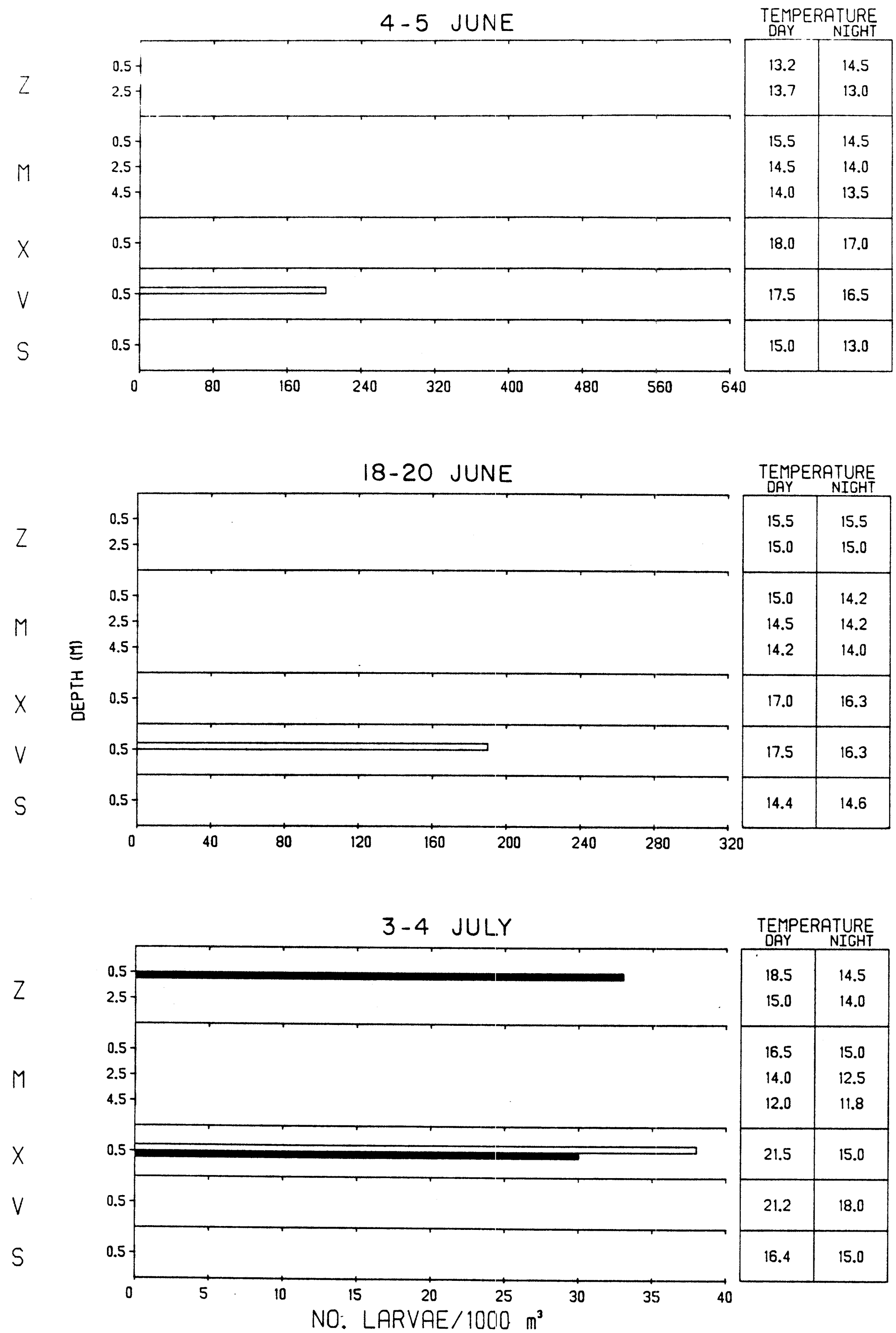
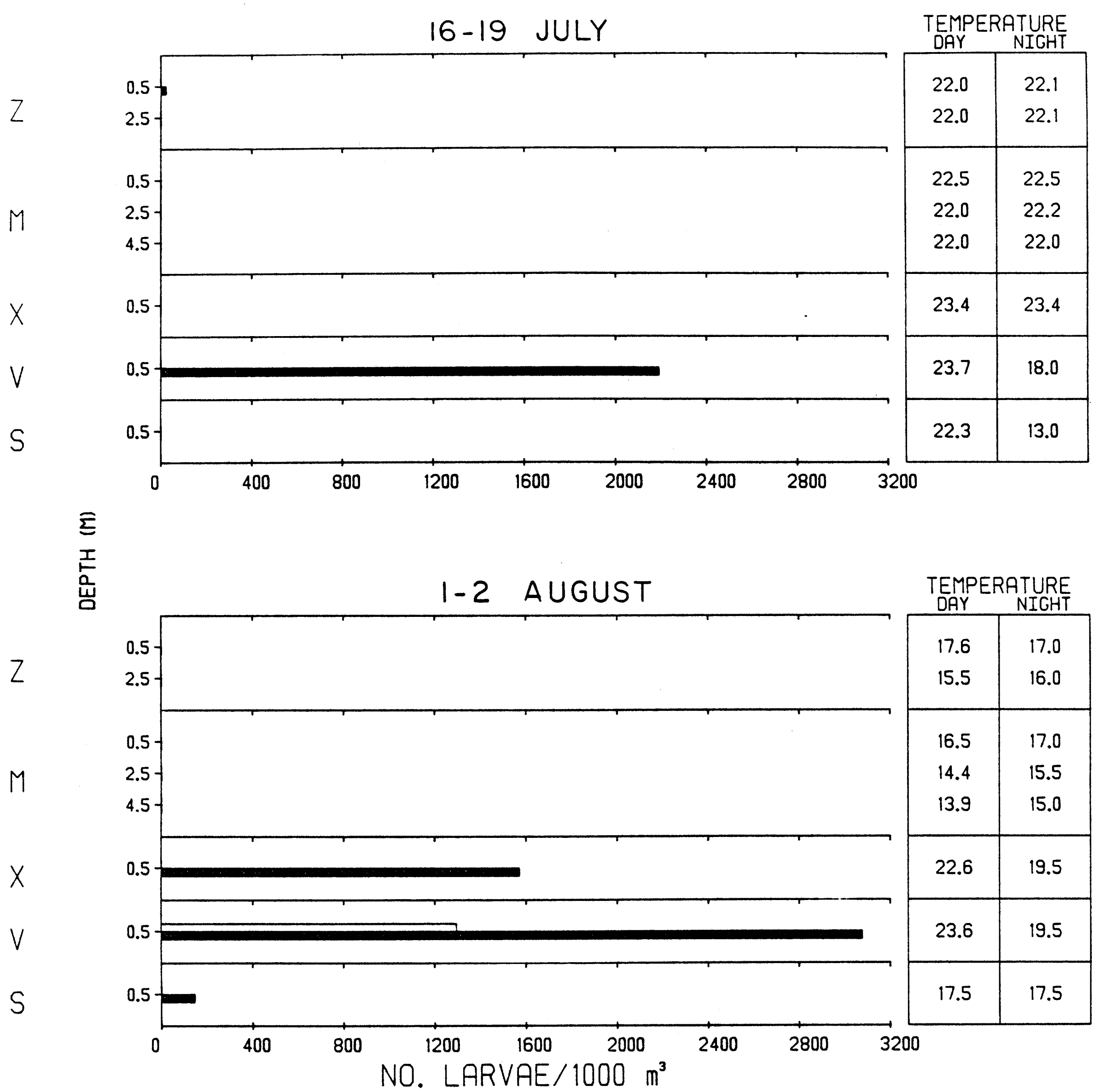


Fig. 107. Density of *Lepomis* spp. larvae (no./1000 m^3) at Pigeon Lake and intake canal stations near the J.H. Campbell Plant, eastern Lake Michigan, April to September 1979. Stations Z(intake canal), M(6 m, openwater), X(1 m, openwater), V(beach, undisturbed) and S(beach, Lake Michigan influenced) are shown. ☐ = day, ■ = night.



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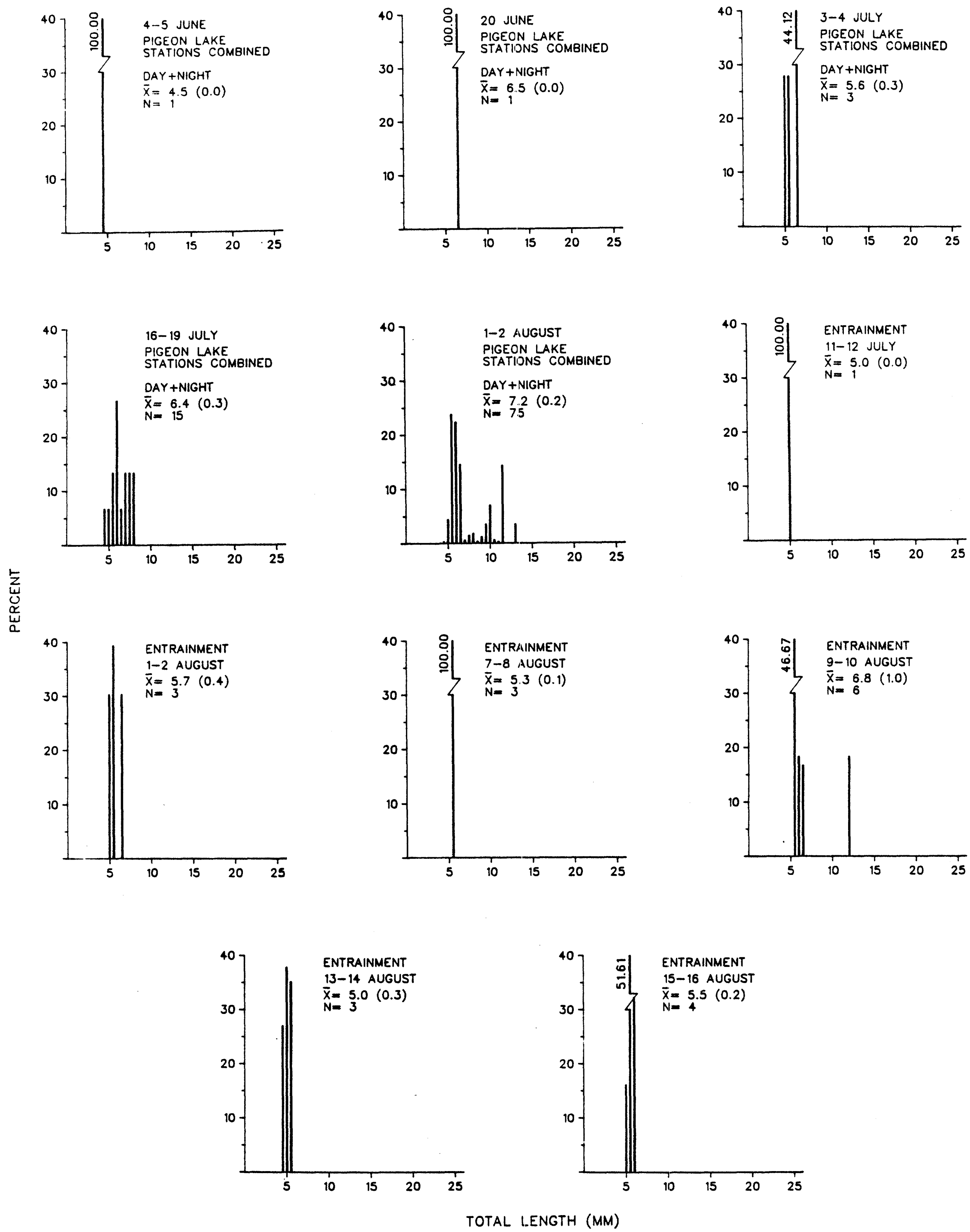


Fig. 108. Length-frequency histograms for Lepomis spp. larvae observed in field and entrainment samples collected during 1979 near the J.H. Campbell Plant, eastern Lake Michigan. $\overline{X}$ = mean, N = total number of larvae collected, standard error is given in parentheses.

Lepomis larvae reached peak abundance in Pigeon Lake during 1-2 August; highest catches (3076 larvae/1000 m^3) occurred at night at beach station V. Substantial numbers of larvae (1286 larvae/1000 m^3) were also caught during the day at this station (Fig. 107). Night tows at station X, located at approximately 3 m in the undisturbed portion of Pigeon Lake, captured *Lepomis* larvae at a density of 1570 larvae/1000 m^3. Werner (1967) reported bluegill larvae moved to the shallow waters of the limnetic area after absorption of the yolk sac at approximately 6 mm. Since bluegill and pumpkinseed spawn mostly in water 35-90 cm (Carlander 1977), *Lepomis* larvae caught at station X probably came from shallow areas. A 6.1-mm *Lepomis* larva was found at night at beach station S (influenced by Lake Michigan) during 1-2 August suggesting that sunfish may utilize this station as a spawning and nursery ground. A 6.8-mm *Lepomis* larva was also collected at Lake Michigan beach station P (south reference) during this period. Like *Pomoxis* larvae, this *Lepomis* larva was probably carried by currents from the discharge canal out into the lake. *Lepomis* larvae collected during 1-2 August ranged from 4.5 to 13 mm (Fig. 108). As was found during July, most larvae collected in August were 6.5 mm and smaller. However, an appreciable number of larvae 7 to 13 mm were found (Fig. 108). More larvae were caught at night than during the day. *Lepomis* larvae were scarce in Pigeon Lake after the 1-2 August sampling period. They were not found in Pigeon Lake during late August and September 1979. No *Lepomis* larvae were collected in Pigeon Lake during August 1978, and only a few were caught during August 1977.

Entrainment--*Lepomis* larvae were not found in entrainment samples during June probably because of their low density in Pigeon Lake during this month. The larvae first occurred in entrainment samples during 11-12 July, when density was 5 larvae/1000 m^3. Despite a substantial increase in hatching during late July, these species were not found in entrainment samples during 13-31 July (Appendix 14). Entrainment remained low throughout August varying from 2 to 4 larvae/1000 m^3 during 1-15 August (Appendix 14). Except for one 11.8-mm larva entrained on 10 August, all larvae collected during 1-15 August were in the 5- to 6.5-mm range (Fig. 108). *Lepomis* larvae larger than 6.5 mm observed in Pigeon Lake during this period were probably able to escape entrainment. *Lepomis* larvae were entrained mostly at night (Fig. 109). They have never been found in day entrainment samples during 1979. Low entrainment was also observed during August 1977 and 1978. Unlike *Pomoxis* larvae, *Lepomis* larvae appeared to be less vulnerable to entrainment probably because *Lepomis* spp. do not spawn in water as deep as *Pomoxis* and because at the time of departure from the nest, *Lepomis* larvae were larger than *Pomoxis* larvae (see Unidentified *Pomoxis* spp).

Rainbow Smelt

Introduction--

Rainbow smelt spawn in tributary streams or in shallow areas of lakes (Scott and Crossman 1973). Eggs are attached by means of a stalk to substrate which may consist of sand, gravel and a variety of other submerged objects (Rupp 1959). Smelt larvae originating in streams are carried by current to lakes soon after hatching (Van Oosten 1940). Near the Campbell Plant, rainbow

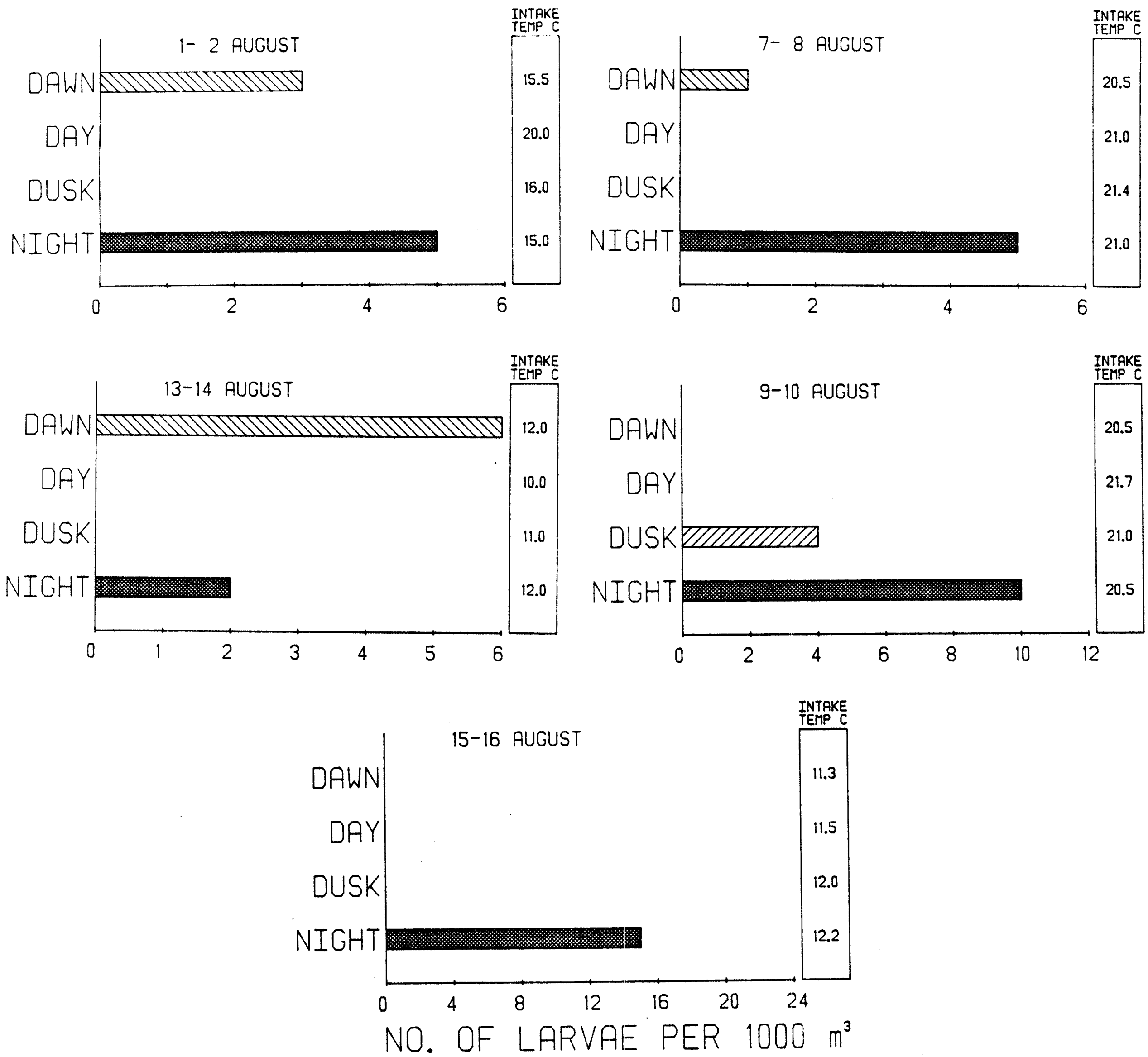


Fig. 109. Density of Lepomis spp. larvae (no./1000 m^3) in weekly dawn, day, dusk and night entrainment samples at the J.H. CAmpbell Plant, eastern Lake Michigan 1979.

smelt spawning takes place in the inshore water of Lake Michigan where most smelt larvae were collected. During 1977-1979 smelt appeared to spawn only sporadically in Pigeon Lake and Pigeon River. Low numbers of smelt larvae were collected in Pigeon Lake during 1977 and 1979. Small numbers of smelt larvae in the inshore water near the Campbell Plant may have drifted from Pigeon Creek located 3 km north of the study area. Some smelt runs have been reported in this creek (John Trimberger, personal communication, Dept. of Natural Resources, Grand Rapids, Mich.).

Seasonal Distribution--

May--Rainbow smelt larvae were first collected during 14-16 May. They ranged from 4.1 to 8.0 mm with the majority (approximately 95%) being 6 mm or less (Fig. 110). Since average hatching length of smelt is estimated at 5.0 mm (Scott and Crossman 1973; Cooper 1978), most smelt larvae collected during 14-16 May were probably newly hatched larvae. Since smelt larvae grow to 6.4 mm 5 days after hatching (Cooper 1978), the larger larvae we collected (6.5-8 mm) were approximately 5-10-days old. These data suggested that the first smelt hatching in the study area took place during the second week of May. During 1978 smelt larvae first hatched at approximately the same time. Smelt larvae collected in Lake Michigan (Fig. 110) and weekly entrainment data (Appendix 14) indicated that peak hatching of smelt larvae during May occurred between 14 and 23 May.

Smelt larvae were dispersed throughout the Lake Michigan study area during May. On the north transect, they were collected at all stations, but appeared to be most abundant in the shallow areas (beach zone to 3 m). Highest day and night densities (respectively 443 and 940 larvae/1000 m^3) occurred at beach station Q (south discharge). Lower larval densities (from 0 to 230 larvae/1000 m^3) were observed at beach station R (north discharge) and station J (3 m, north). No smelt larvae were collected at station I (1.5 m, north). Smelt larvae were caught at all deeper stations (6-15 m) with densities ranging from 0 to 27 larvae/1000 m^3 (Fig. 111).

Smelt larvae were not found in the beach zone or at 1.5-m station A on the south transect. Larval densities increased progressively from 21/1000 m^3 at the 2.5-m stratum at station B (3 m, south) to 65/1000 m^3 at the 6.5-m stratum at station D (9 m, south). Low numbers of smelt larvae were caught at 12 and 15 m on the south transect (Fig. 111). No difference in size between larvae caught in the shallow water (beach zone to 3 m) and those collected in deeper water (6 m to 15 m) was observed during May.

Rainbow smelt were reported to spawn in shallow water (Rupp 1959; Jude et al. 1975). Beach spawning was observed in the study area during May 1978. Abundance of smelt larvae at beach station Q (south discharge) suggested that spawning also took place in the beach zone during April and May 1979. During 1978 smelt larvae were observed to disperse offshore soon after hatching (Jude et al. 1979a). Absence of larvae from station P (south reference) and low catches at station R (north discharge) may be due to dispersal of most larvae to deeper water.

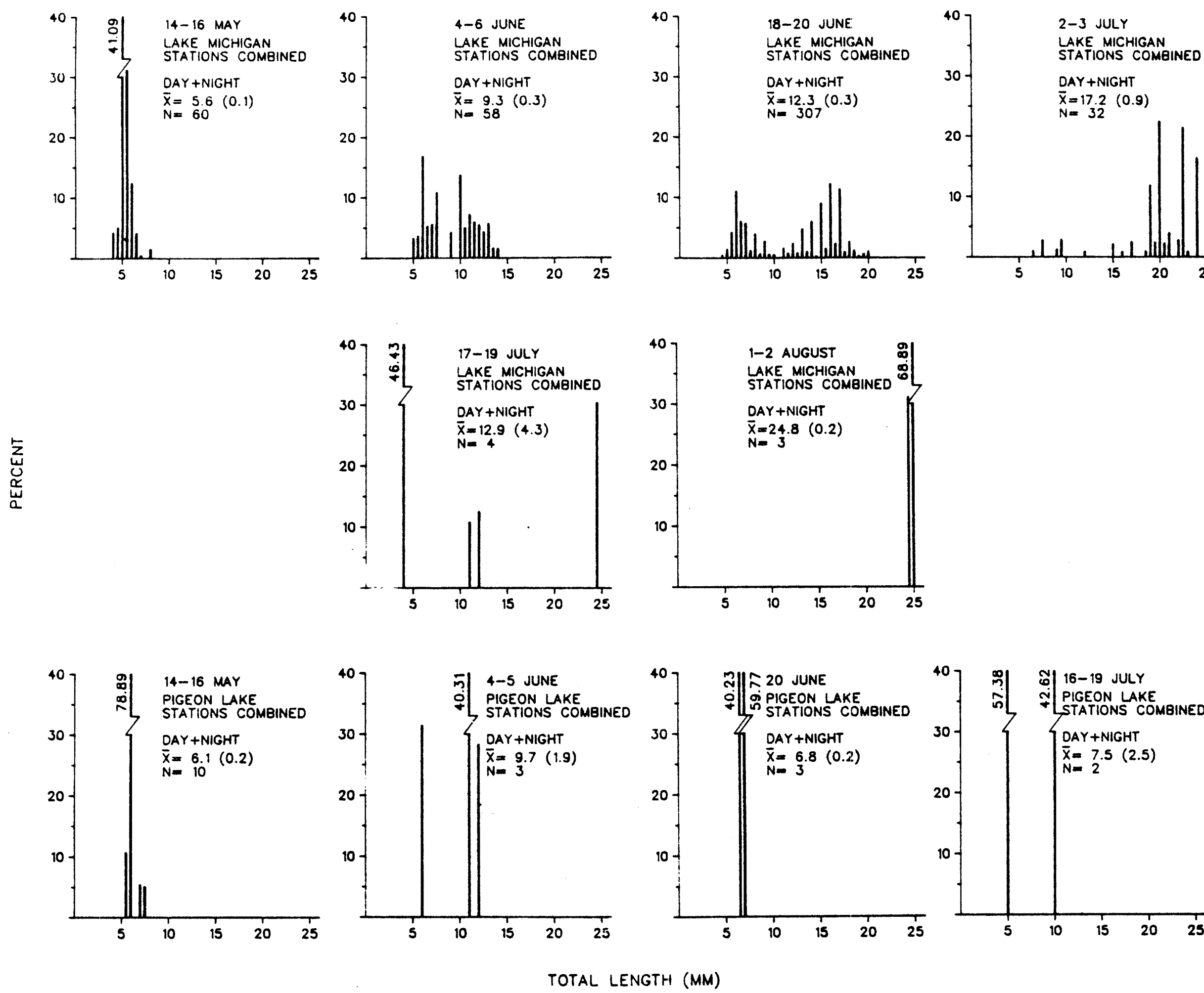
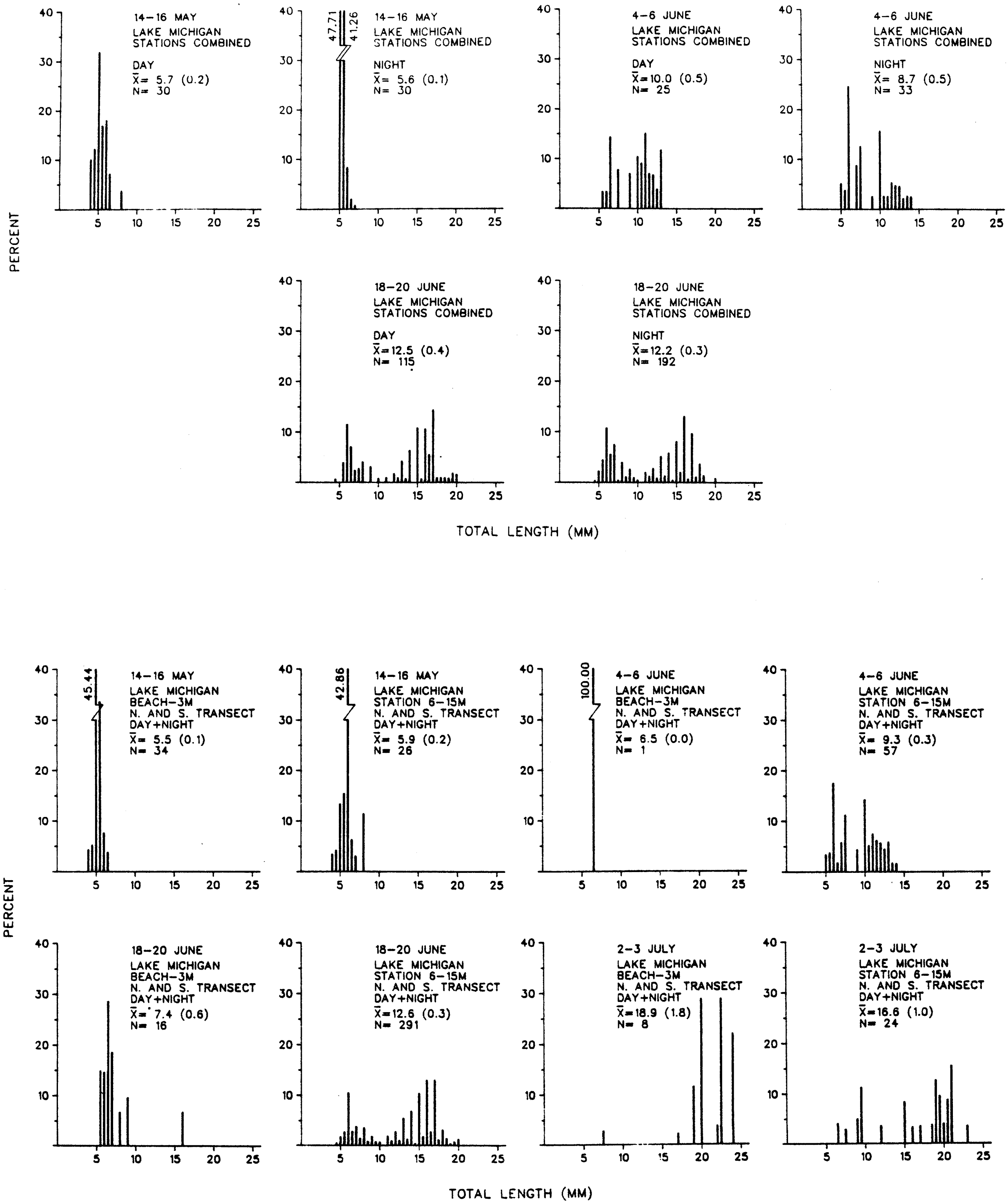


Fig. 110. Length-frequency histograms for larval rainbow smelt observed in field and entrainment samples collected during 1979 near the J.H. Campbell Plant, eastern Lake Michigan. $\overline{X}$ = mean, N = total number of larvae collected, standard error is given in parentheses.

Smelt larvae were caught only at a few strata sampled at stations outside the beach zone. Diel vertical migration reported by Jude et al. (1978, 1979b) did not occur in the study area during May. Smelt larvae could be found near the bottom during the day and near the surface at night or vice versa (Fig. 111). Day and night tows captured larvae of similar sizes (Fig. 110), suggesting no daytime net avoidance by larvae in the 4.0-8.0-mm range.

Smelt larvae were caught in appreciable numbers in Pigeon Lake during May. At station M (influenced by Lake Michigan), smelt larvae occurred at the 2.5- and 4.5-m strata during the day and at night in densities ranging from 40 to 110 larvae/1000 m³ (Fig. 112). No larvae were collected at the surface



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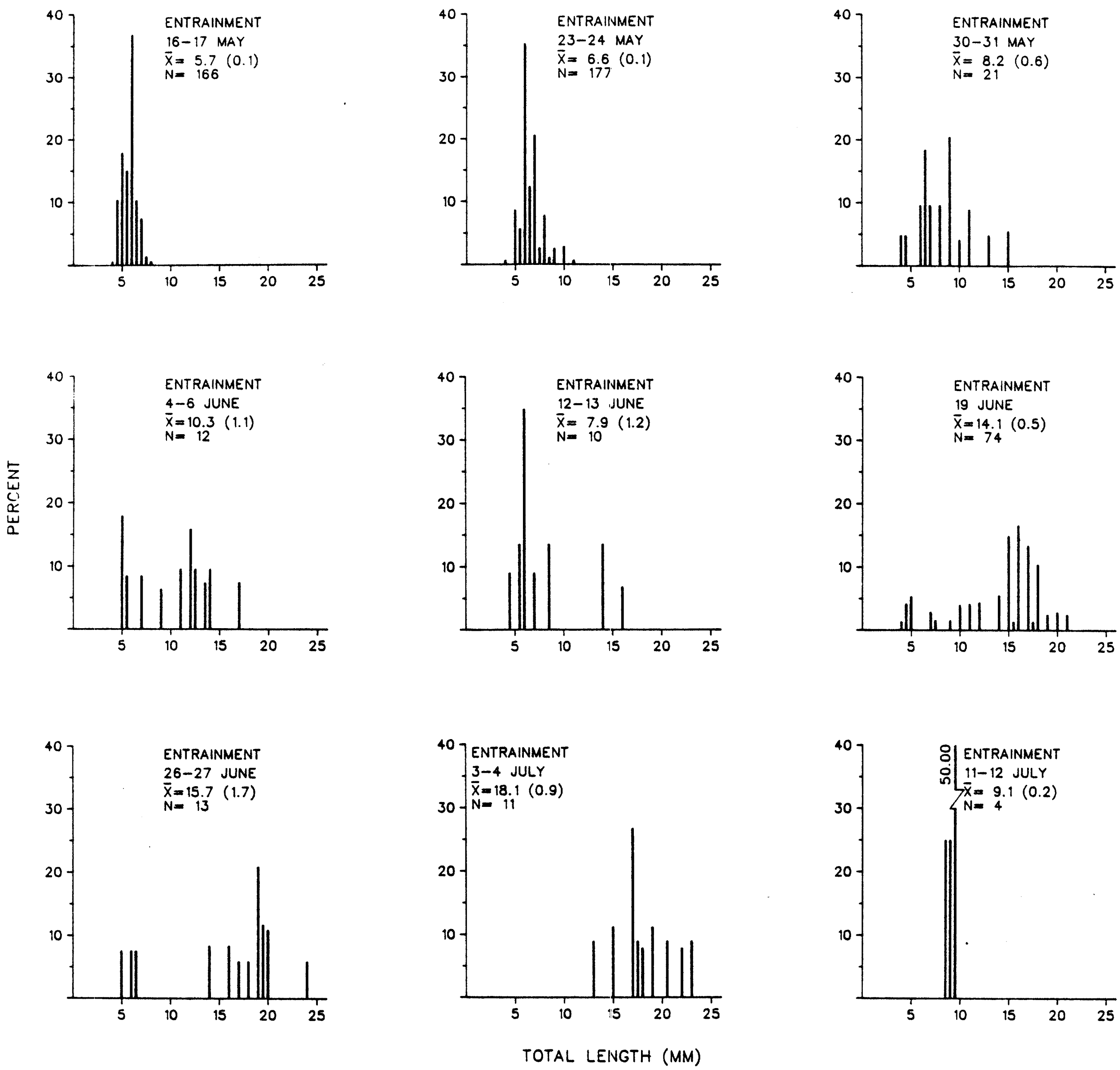

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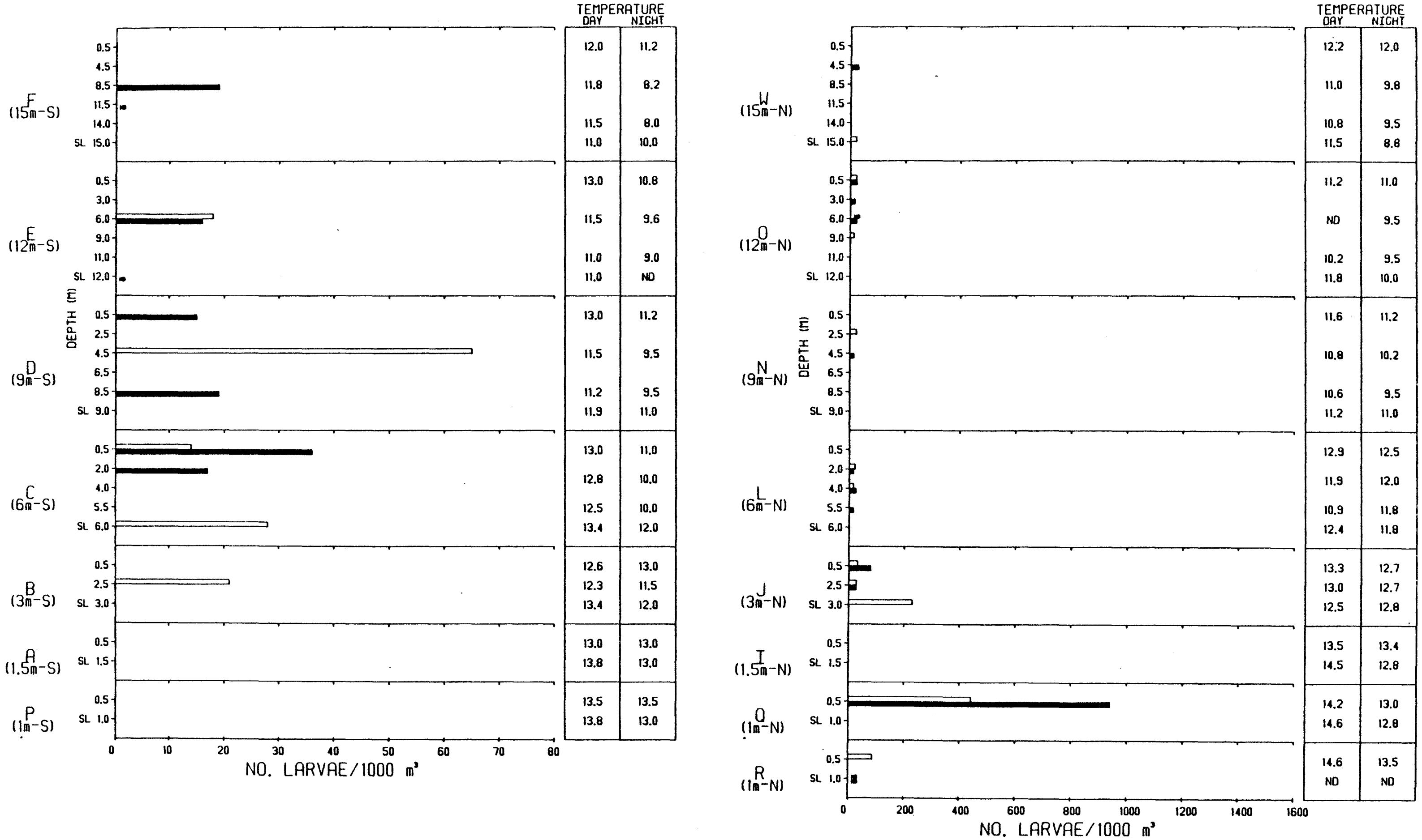


Fig. 111. Density of larval rainbow smelt (no./1000 m^3) at Lake Michigan stations near the J.H. Campbell Plant, eastern Lake Michigan, 16-17 May 1979. □ = day, ■ = night, SL = sled, ND = no data.

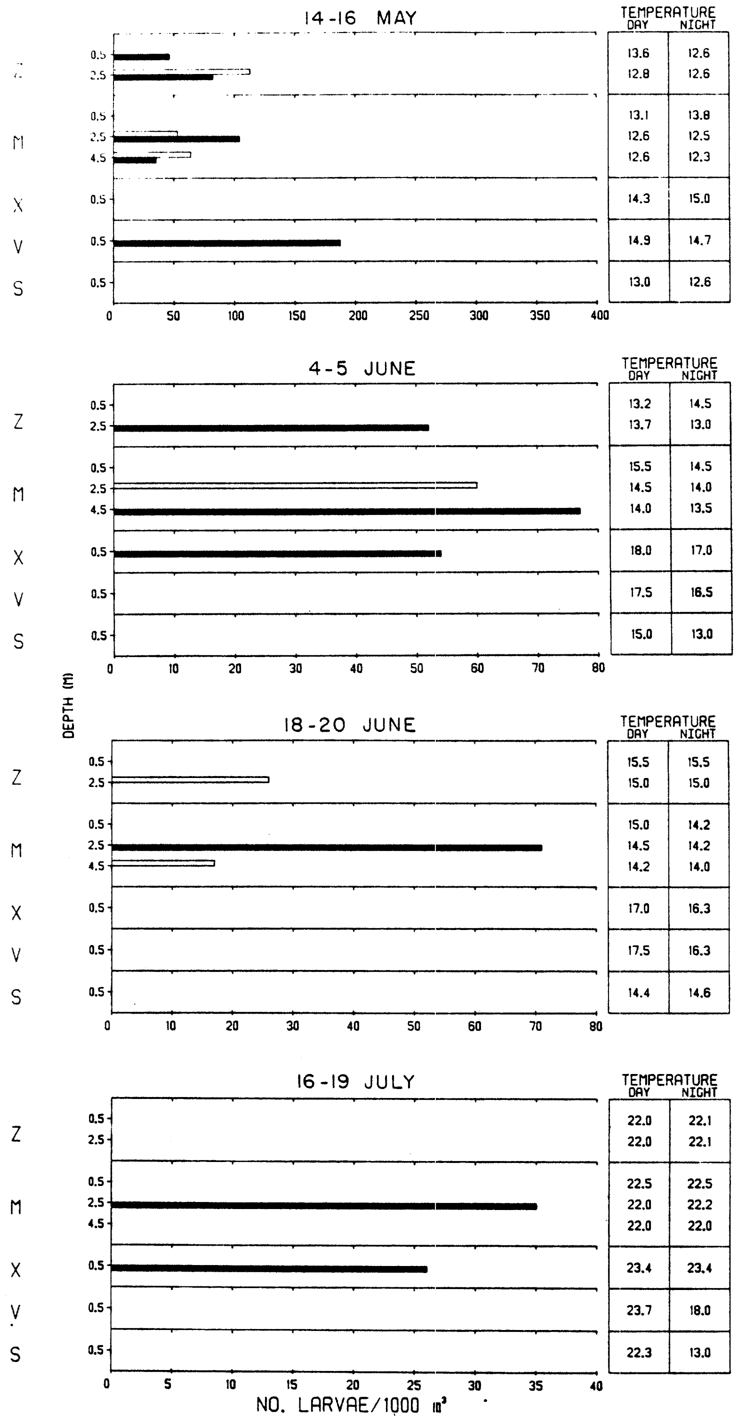


Fig. 112. Density of larval rainbow smelt (no./1000 m^3) at Pigeon Lake and intake canal stations near the J.H. Campbell Plant, eastern Lake Michigan, May to July 1979. Stations Z(intake canal), M(6 m, openwater), X(1 m, openwater), V(beach, undisturbed) and S(beach, Lake Michigan influenced) are shown. ☐ = day, ■ = night.

stratum at station M. Substantial numbers of smelt larvae were also collected at station Z (intake canal). Night tows captured smelt larvae in densities of 49 larvae/1000 m^3 near the surface and approximately 80 larvae/1000 m^3 near the bottom. During the day, larvae were caught only near bottom; density was 120 larvae/1000 m^3. Larvae collected at stations M and Z ranged from 5 to 7.5 mm (Fig. 110). All were probably drawn from Lake Michigan.

Smelt larvae (6.0 mm) occurred at beach station V (undisturbed Pigeon Lake) at a density of 180 larvae/1000 m^3 (Fig. 112). Since a few ripe-running smelt have been found in Pigeon Lake catches or in impingement samples (Jude et al. 1979a), these larvae could possibly have resulted from spawning in Pigeon Lake. In Pigeon Lake and in the intake canal, more smelt larvae were caught at night than during the day. A small number of rainbow smelt, 50-62 mm, undoubtedly yearlings, were also caught in plankton nets and larval sleds in Lake Michigan during April and May.

June--Smelt larvae were scarce in the shallow areas (beach zone to 3 m) during 4-6 June. On the south transect, smelt larvae were caught only from 6 to 15 m in densities ranging from 0 to 115 larvae/1000 m^3. The highest density of larvae was observed at the bottom stratum at 9-m station D (Fig. 113). On the north transect, larvae were caught from 3 to 15 m in densities ranging from 0 to 75 larvae/1000 m^3. Peak catch occurred in a day tow at the 3-m stratum at station O (12 m, north). On both the south and north transects, smelt larvae were most abundant at 9 and 12 m (Fig. 113). Scarcity of smelt larvae in the shallow area (beach zone to 3 m) substantiates Jude et al. (1975) who reported smelt larvae move offshore after a short residence in the beach zone. During 4-6 June average density of smelt larvae on the south transect (7 larvae/1000 m^3) was comparable to that observed on the north transect (9 larvae/1000 m^3).

Smelt larvae collected during 4-6 June ranged from 5 to 14 mm. Two size groups of larvae were represented in early June samples. Recently hatched larvae 5-7.5 mm comprised a large portion of the total larvae collected (Fig. 110), suggesting that substantial hatching took place during and shortly before 4-6 June. Larger larvae (9-14 mm) probably hatched during the second and third week of May. During early June 1978 a comparable size range of smelt larvae (5-15 mm) was found in the study area.

Although rainbow smelt generally spawn in shallow water (Rupp 1959, 1965), spawning was reported in water 9 to 22 m in Lake Erie (MacCallum and Regier 1970). Adult and larval fish data from May and June 1978 (Jude et al. 1979a) suggested that some spawning may also take place in deep water (6-15 m) in the study area. Absence of newly hatched larvae in the beach zone and their concentration at deeper stations during early June 1979 (Fig. 100) served as further evidence of deep water spawning by rainbow smelt.

On the north transect, average larvae densities were approximately the same during the day (8 larvae/1000 m^3) as at night (9 larvae/1000 m^3). On the south transect, more larvae were caught at night than during the day (Fig. 113). Larvae of similar sizes were caught at night and during the day on this transect indicating that no net avoidance occurred during the day. Higher

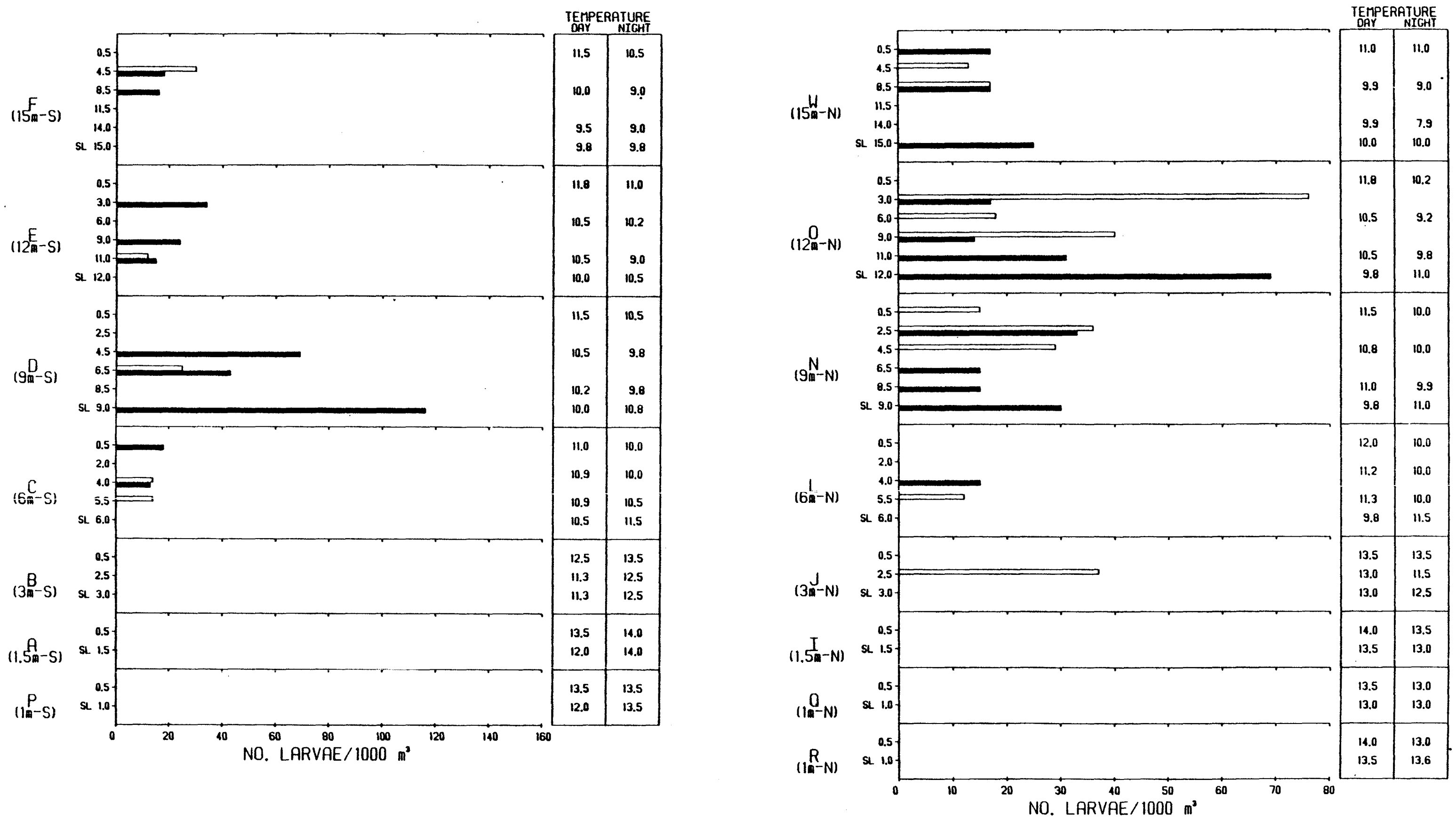


Fig. 113. Density of larval rainbow smelt (no./1000 m^3) at Lake Michigan stations near the J.H. Campbell Plant, eastern Lake Michigan, 4-6 June 1979. ☐ = day, ■ = night, SL = sled.

night catches were probably due to greater activity at night. At deep water stations (6-15 m) on both the north and south transects, night sampling captured larvae at more strata than day sampling (Fig. 113). These data agreed with Emery (1973) who observed that larval smelt were widely dispersed in the water column at night.

In Pigeon Lake, smelt larvae were less abundant during June than during May (Fig. 112). At station M (influenced by Lake Michigan), smelt larvae 6 and 12 mm (Fig. 110) were caught at 2.5 m during the day and at 4.5 m at night in densities of 60 and 70 larvae/1000 m^3, respectively. Night plankton net tows also captured smelt larvae approximately 12.5 mm near the bottom (2.5 m) of the intake canal (station Z); density was 53 larvae/1000 m^3. Unlike May findings, no smelt larvae were caught in the intake canal during the day. Decline of densities of larvae in Pigeon Lake and in the intake canal during early June was due to lower larval abundance in Lake Michigan. Smelt larvae approximately 11 mm were also caught at a density of 54 larvae/1000 m^3 at station X (undisturbed Pigeon Lake) during early June. Since smelt may spawn in Pigeon Lake or Pigeon River, smelt larvae caught at this station may have hatched in this tributary water.

Lake Michigan catches of larval smelt in 1979 reached a peak during 18-20 June. Smelt larvae were widely distributed in the inshore area. During the day they occurred from 1.5 to 15 m on both north and south transects. No larvae were caught during the day at station B (3 m, south). At night, smelt larvae were found from the beach zone to 15 m on both transects (Fig. 114). As was found during early June, larval abundance generally increased toward deeper stations (Fig. 114). Highest density on the north transect (290 larvae/1000 m^3) occurred at the 8.5-m stratum at station N (9 m, north). On the south transect, larvae were most abundant (490 larvae/1000 m^3) at the 4.5-m stratum at station F (15 m, south). These high densities at deep water stations suggested smelt larvae may be dispersed into deeper water outside our study area. During June 1977, smelt larvae were found at 18 and 21 m (Jude et al. 1978).

Smelt larvae collected during 18-20 June ranged from 4.5 to 20 mm. Occurrence of newly hatched larvae 4.5-6.0 mm during late June indicated that, like 1977 and 1978, smelt spawning extended into early June in 1979. These data agreed with McKenzie (1958) who observed smelt spawning until early June in the Miramichi River, New Brunswick. As was found during 4-6 June, most small larvae 5-7 mm were found in deep water. Very few newly hatched larvae occurred from the beach zone to 3 m (Fig. 110).

Length-frequency distribution of larval smelt collected during 18-20 June showed two size groups to be most abundant which corresponded to two peak hatchings between the second week of May and 20 June (Fig. 110). The first abundant group of larvae included individuals 14-18 mm. Since smelt larvae of this size range were approximately 1-mo old (Kendall 1927), the first hatching peak took place 1 mo prior to 18 June, approximately around 18 May. These data agreed with the peak hatching date of 14-23 May inferred from data derived from field and entrainment samples collected during May. The second abundant group of larvae consisted mostly of newly hatched larvae (5.5-7.5 mm)

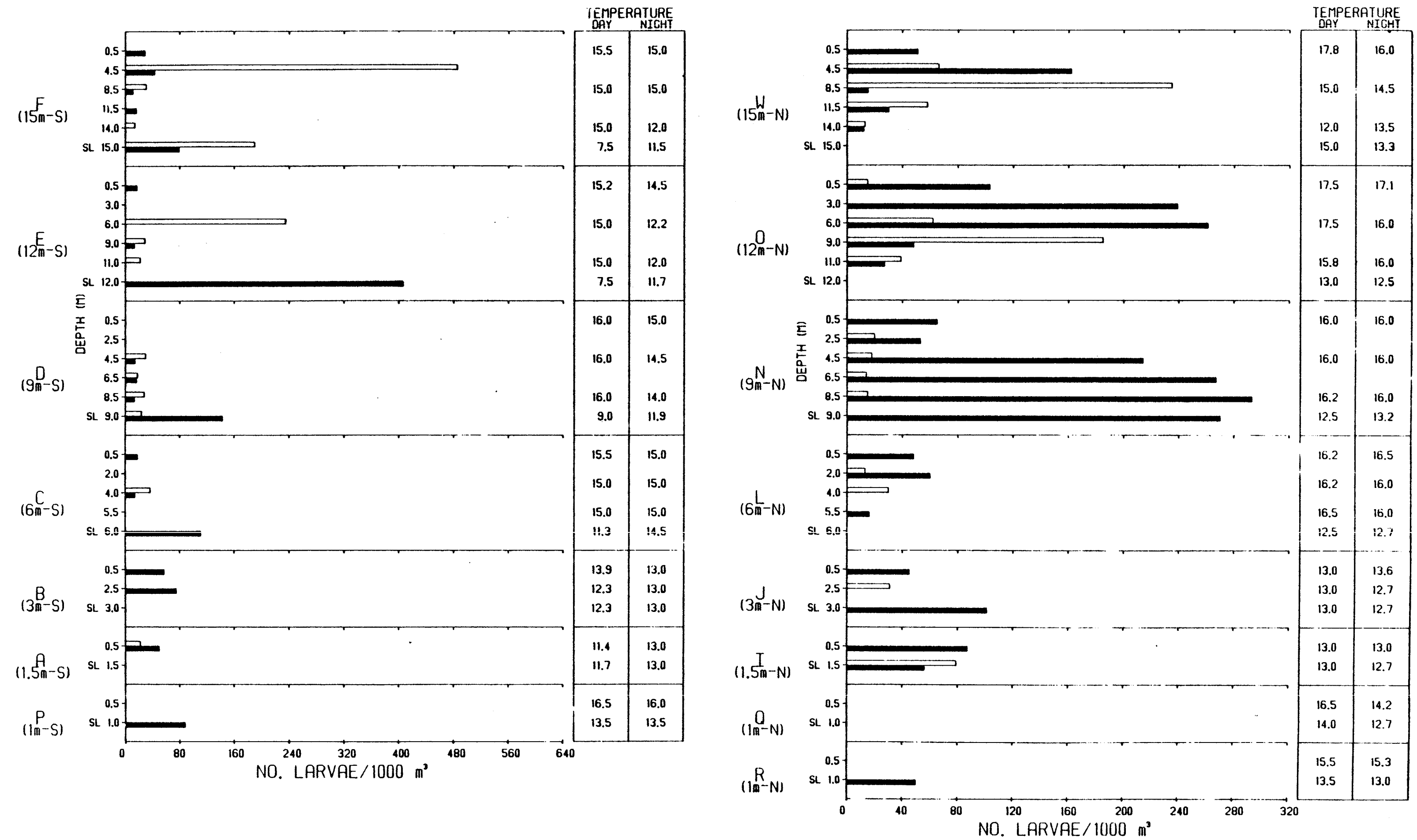


Fig. 114. Density of larval rainbow smelt (no./1000 m^3) at Lake Michigan stations near the J.H. Campbell Plant, eastern Lake Michigan, 18-20 June 1979. ☐ = day, ■ = night, SL = sled.

(Fig. 110). As had been discussed previously, the largest individuals in this group (6.5-7.5 mm) were approximately 5-10-days old. These data indicated that the second peak hatching of smelt larvae probably occurred within 1 wk prior to the 18-20 June sampling period. Length-frequency distribution of larvae collected during 18-20 June suggested that the second peak hatching was much less important than the first (Fig. 110).

The two hatching peaks may in part correspond to the spawning peaks during April and May. As has been discussed with adult smelt (see ADULT AND JUVENILE FISH, Rainbow Smelt), only low numbers of adult smelt were caught during the spawning season because our field sampling did not coincide with peak runs. Incubation time of rainbow smelt eggs varies inversely with water temperature, ranging from 29 days at 6-7 C (MacKenzie 1964) to 8 days at 16.5 C (Cooper 1978). Increased water temperatures in the inshore area during June may also cause a hatching peak as large numbers of eggs began to hatch during a short time.

Smelt larvae were distributed in more strata during 18-20 June than previous sampling periods. Smelt larvae appeared to exhibit a more distinct diel vertical migration during 18-20 June than during previous periods. They were commonly caught near the surface at night, but at lower densities than at lower depth levels. During the day, they were caught at the surface only at two stations, station O (12 m, north) and station A (1.5 m, south). Both during the day and at night, larvae tended to concentrate in mid-water strata or near bottom. As was found during early June, smelt larvae occupied more strata at night than during the day (Fig. 114).

On the south transect, average larval densities were approximately the same during the day (37 larvae/1000 m^3) as during darkness (38 larvae/1000 m^3). On the north transect, however, average night density (74 larvae/1000 m^3) was substantially higher than average day density (26 larvae/1000 m^3). No difference in size between larvae caught during the day and those caught at night was observed during late June indicating that no net avoidance took place during the day.

Small numbers of smelt larvae continued to occur in Pigeon Lake and the intake canal during late June (Fig. 112). At 6-m station M (influenced by Lake Michigan), they were caught during the day at 4.5 m at a density of 18 larvae/1000 m^3. Night tows at station M captured smelt larvae at the 2.5-m stratum where density was 73 larvae/1000 m^3. Smelt larvae were also caught at the 2.5-m stratum at station Z (intake canal) during the day; density was 28 larvae/1000 m^3. Rainbow smelt larvae collected in Pigeon Lake and the intake canal (Fig. 110) were approximately the same size (5.5-7 mm) as the small larvae we observed in the shallow area of Lake Michigan during late June. Larger larvae were also drawn into Pigeon Lake during this period, as several larvae 8-20 mm were found in entrainment samples collected on 19 June (see Entrainment, this section). They were probably able to avoid our plankton nets during field sampling in Pigeon Lake.

Very few smelt larvae reached 25.4 mm or larger size during June. Only one 37-mm fish was collected during this month.

July--Smelt larvae occurred in lower abundance during early July than during June. On the north transect, they were scattered in small numbers from the beach zone to 12 m during the day and were concentrated mainly in the beach zone at night (Fig. 115). Highest day and night densities (respectively 267 and 610 larvae/1000 m^3) were observed at beach station Q (south discharge). Smelt larvae were also caught at 6, 12 and 15 m at night on the north transect. On the south transect, larvae were restricted to 6 m and deeper at night. They were found at 6 and 9 m during the day (Fig. 115).

Smelt larvae collected during early July ranged from 6.5 to 24 mm, the majority being relatively large (15-24 mm) (Fig. 110). Since large larvae can effectively avoid plankton nets and the larvae sled, decline of larvae catches we observed during 2-3 July may be due to net avoidance. The higher density of larvae found in the beach zone on the north transect was probably due to higher water temperatures (9.6-12.4 C) than at deeper stations (5.5-11.0 C).

Most smelt larvae collected during 2-3 July were 19-24 mm. These larvae were probably part of the cohort that hatched around the third week of May. They were also the dominant size group (14-18 mm) during late June. No newly hatched larvae were caught during early July. Smelt larvae 6.5-12 mm which occurred in small numbers during 2-3 July (Fig. 110) probably hatched about 3 wk before our early July sampling. These larvae were probably part of the cohort that reached 4.5-7.0 mm during late June (Fig. 110). Low catches of larvae 6.5-12.0 mm supported our previous observations on the relatively low abundance of this cohort. One 29-mm smelt fry occurred in a plankton net tow at station D (9 m, south) during early July.

Smelt larvae were scarce in the study area during 17-19 July. Small larvae (4 mm) were caught (density 52/1000 m^3) at beach station R (north discharge) during the day. Large smelt larvae (11-24.5 mm) were caught in small numbers at stations I (1.5 m, north), W (15 m, north) and D (9 m, south) (Fig. 116). Newly hatched larvae have not been caught in the study area during late July in 1977 and 1978. Occurrence of 4-mm larvae during 17-19 July suggested that smelt spawning may take place during late June; such an occurrence is quite exceptional based on our previous work.

Most larvae that hatched during May and early June were probably larger than 25.4 mm by this time and were classified as fry. Smaller larvae (11-25.4 mm) probably belonged to the cohort that hatched during late June. Low catches of smelt larvae 11-25.4 mm during 17-19 July suggested that this cohort represented only a small portion of the total larval smelt population.

No smelt larvae were caught in Pigeon Lake during 2-3 July. However, a small number of larvae were found during 17-19 July. At station M (influenced by Lake Michigan) smelt larvae (5 mm) were caught only in the night tow at the 2.5-m stratum. Larval density at this location was approximately 35 larvae/1000 m^3. As previously discussed, these newly hatched larvae probably resulted from spawning during late June in Lake Michigan. Slightly larger smelt larvae (10 mm) also occurred at a density of 26 larvae/1000 m^3 at station X (undisturbed Pigeon Lake). As previously discussed, these larvae may have hatched in Pigeon Lake or Pigeon River.

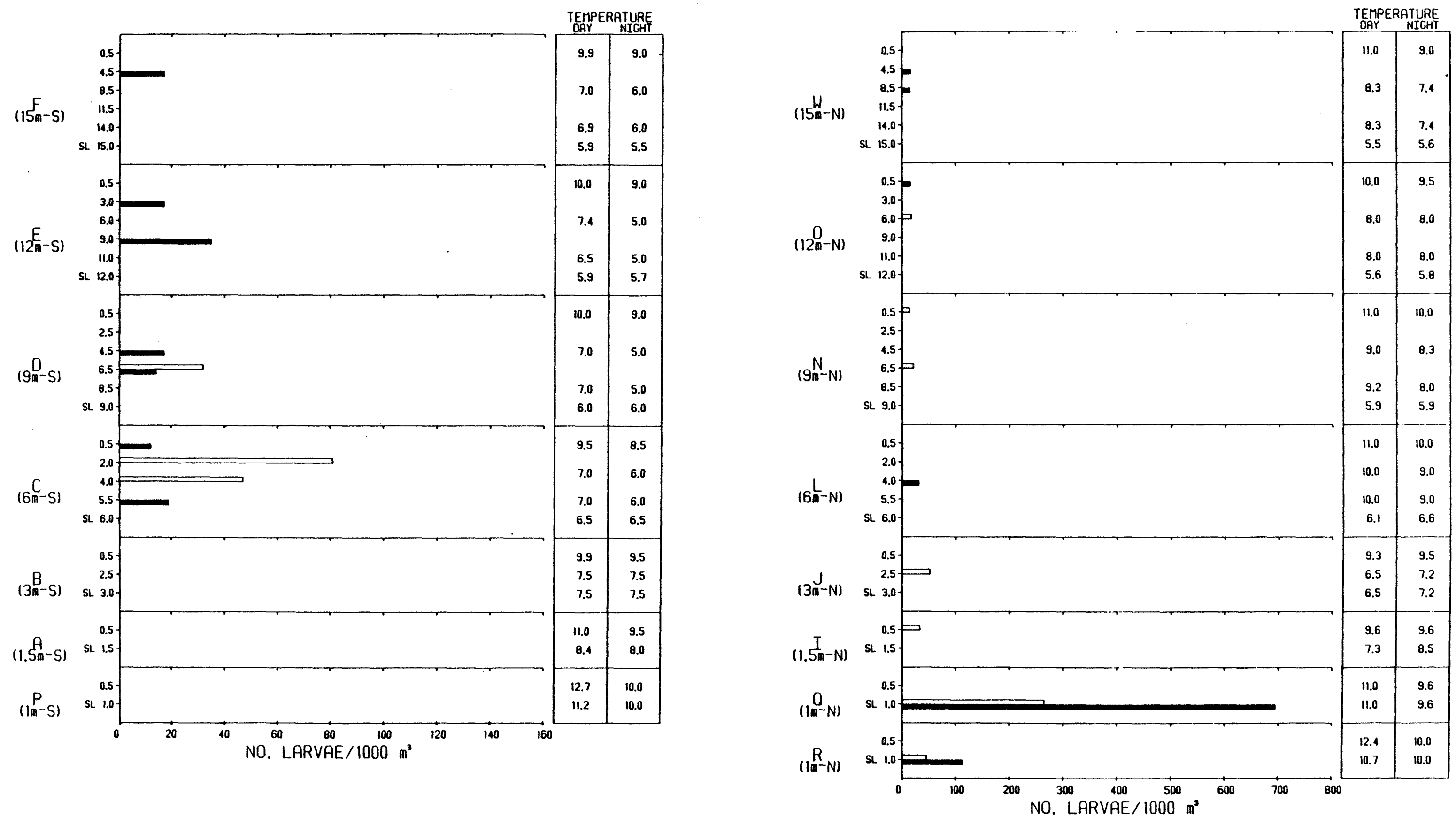


Fig. 115. Density of larval rainbow smelt (no./1000 m^3) at Lake Michigan stations near the J.H. Campbell Plant, eastern Lake Michigan, 2-3 July 1979. ☐ = day, ■ = night, SL = sled.

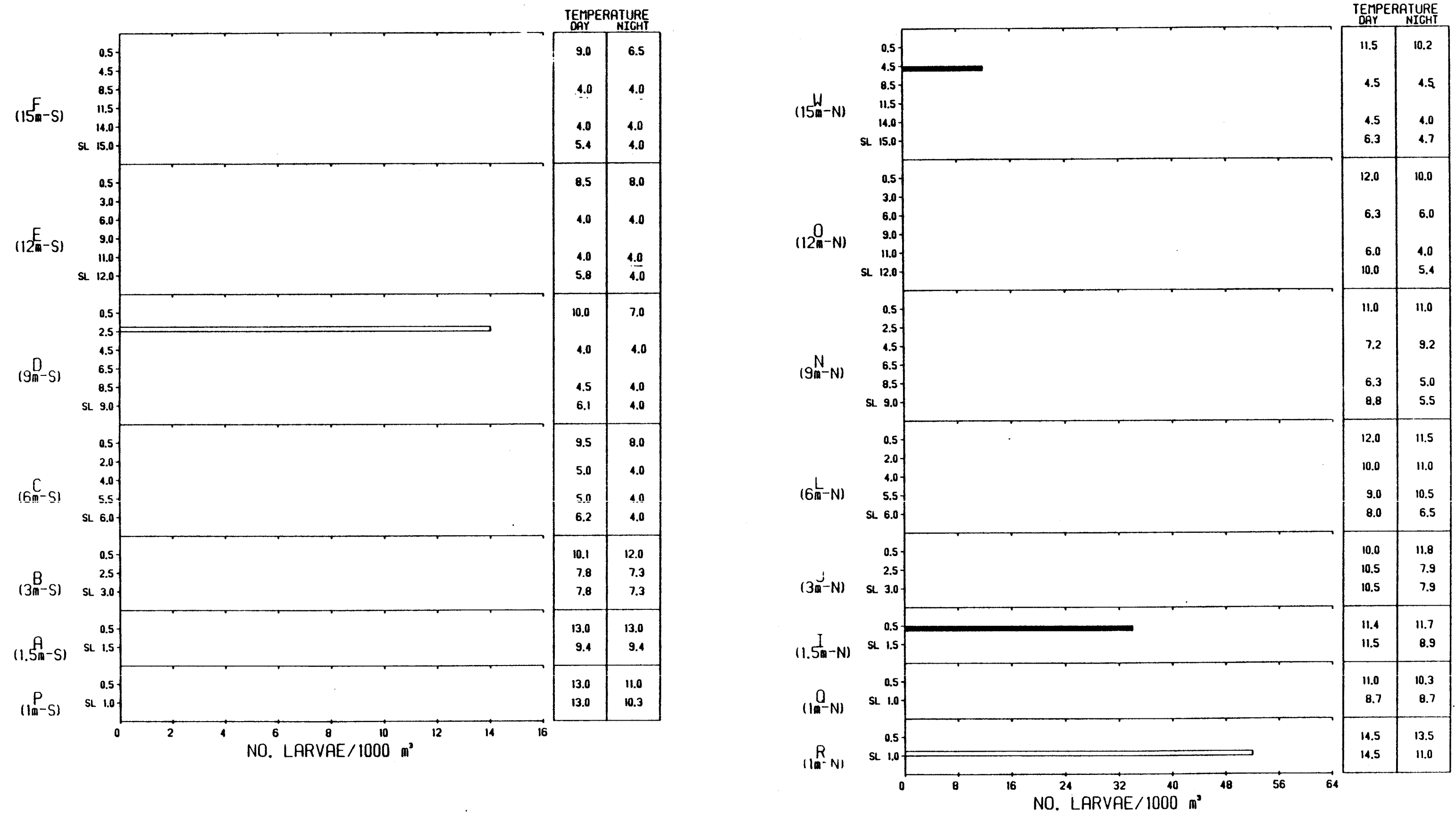


Fig. 116. Density of larval rainbow smelt (no./1000 m^3) at Lake Michigan stations near the J.H. Campbell Plant, eastern Lake Michigan, 17-19 July 1979. ☐ = day, ■ = night, SL = sled.

More smelt fry (27-91 mm) occurred in plankton nets and larval sleds during 17-19 July than during early July. On the north transect, fry occurred in the beach zone and at the 1.5-, 6- and 12-m contours. On the south transect, they were found only at 3 and 6 m. More fry were caught in the nearshore area (beach zone to 3 m) than in deeper water (6-15 m) (Appendix 15). Highest fry density (351 fry/1000 m^3) was found at beach station R (north discharge). As was found with smelt larvae during late July, smelt fry were probably attracted to relatively warm water available in the shallow area at the north transect. Most smelt fry occurred at night; those collected during the day were found mostly near bottom. These data indicated that smelt fry avoided plankton nets during the day.

Smelt fry 27-38 mm collected during late July were probably members of the cohort that hatched during the third week of May and were approximately 2-mo old by 17-19 July. Size range of these fry (27-38 mm) agreed with the length of 27-34 mm reported for 2-mo-old smelt YOY (Bigelow and Schroeder 1963). Larger smelt fry 68-91 mm which occurred in late July field samples were yearlings.

August--Smelt larvae were scarce in the inshore area during August, being caught only at the 15-m contour on the north and south transects during 1-2 august (Appendixes 10 and 11). These larvae were 24.5-25 mm. No smelt larvae were collected in Pigeon Lake during 1-2 August or anywhere in the study area after the August sampling period.

As was found during August 1977 and 1978, appreciable numbers of smelt fry were caught in plankton nets and larvae sleds during early and late August 1979. In 1979 smelt fry (26-41 mm) were more common in the inshore area during August than during late July. During early and late August, smelt fry occurred from the beach zone to 15 m both on the south and north transects (Appendix 15). They were more abundant in the nearshore zone (beach zone to 3 m) than at deeper stations (6-12 m). Highest catches (1226 fry/1000 m^3) were found at beach station Q (south discharge). Both in the shallow and deep water areas, more fry were caught near bottom than in upper strata. Smelt fry (32-49.5 mm) were also found in plankton net and sled catches during September, but were less abundant than during August (Appendix 15). Substantial numbers of smelt fry were also observed during August and September 1977 and 1978. As was found in August, most fry were caught near bottom during September. During 1977-1978 smelt fry 29-45 mm were also collected in large numbers in bottom trawls during August and September. These data agreed with Wells (1968) who reported YOY smelt moved from the upper levels to the bottom during late summer and fall. Depth distribution of fry 26-50 mm was discussed in detail in the ADULT AND JUVENILE FISH section.

Low numbers of YOY smelt 29.5-38 mm were also caught in Pigeon Lake during August and September (Appendix 15). Smelt fry approximately 97 mm collected during August were yearlings. No smelt fry were collected during the remainder of 1979.

Entrainment--

May--Smelt larvae first appeared in weekly entrainment samples during 16-17 May. As has been pointed out in the previous section (see Seasonal Distribution), smelt hatching in Lake Michigan probably took place several days before 16 May. Due to temporary interruption of operation of the Campbell Plant, no weekly entrainment sampling was performed during 8-11 May. During 16-17 May smelt larvae were entrained at a rate of approximately 54,370 larvae/24 h (69 larvae/1000 m^3). A similar smelt larvae density (64 larvae/1000 m^3) was observed in the intake canal during the same period. Peak entrainment density of 90,485 larvae/24 h (82 larvae/1000 m^3) occurred during 23-24 May (Fig. 117). A slightly higher density (141,000 larvae/24 h) was recorded during peak entrainment in 1978. Larval smelt entrainment declined to 7391 larvae/24 h during 30-31 May.

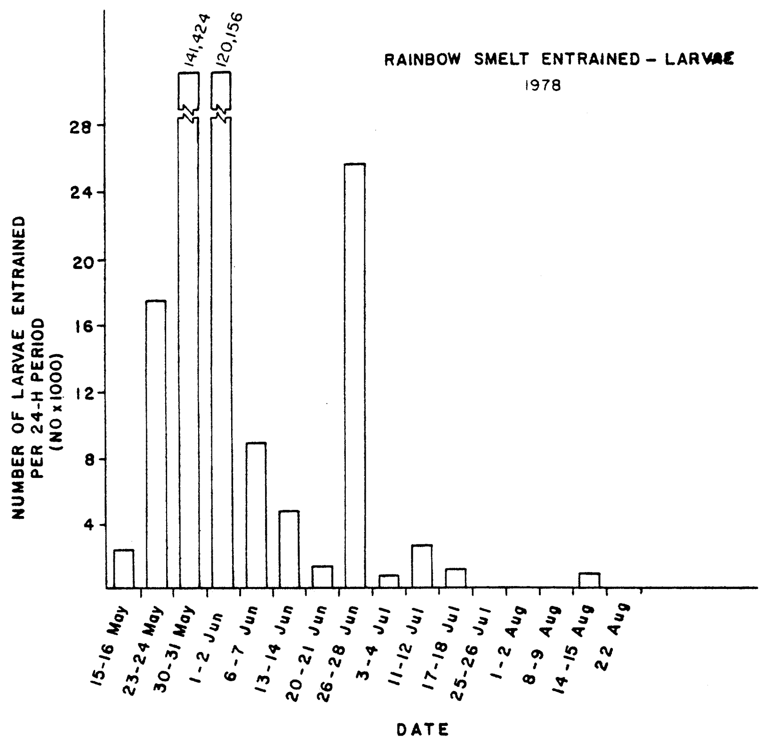
Smelt larvae entrained during 16-17 May were approximately the same sizes (4-8mm) as those collected in Lake Michigan during the same period. Larvae of a slightly wider size range (4-11 mm) were entrained during 23-24 May, but most were newly hatched (4-7 mm) (Fig. 110). These data indicated that increased larval smelt entrainment during 23-24 May was caused by an increase in smelt hatching in Lake Michigan during the third week of May (see Seasonal Distribution).

Size range of smelt entrained during 30-31 May 1979 was 4-15 mm (Fig. 110). Newly hatched larvae (4-7 mm) continued to occur in entrainment samples during this period, but at a lower percentage than during 23-24 May. These data indicated smelt hatching continued to take place the last 2 wk of May.

Smelt larvae were found in entrainment samples during all diel periods during May. Highest entrainment density tended to occur during darkness (dawn, dusk, night) (Fig. 118). During the period of peak entrainment, however, substantial larval catches occurred during the day. A small number of yearling smelt (52 mm) were also entrained during May.

June--Smelt larvae continued to be entrained in low densities (5133 and 5958 larvae/24 h) during 4-6 and 12-13 June. Peak June entrainment of smelt larvae (27,192 larvae/24 h) was observed on 19 June (Fig 117). Smelt entrainment declined to 6150 larvae/24 h during 26-27 June. Low entrainment during June may be related to offshore movement of smelt larvae in Lake Michigan. Similar decrease of smelt entrainment during June also occurred in 1978.

Newly hatched larvae (4-7 mm) were found in entrainment samples throughout June. Peak June entrainment of smelt larvae occurred at approximately the same time as the peak larvae catches in Lake Michigan (see Seasonal Distribution). Larvae entrained on 19 June were approximately the same size (4-21 mm) as those collected in Lake Michigan during 18-20 June (Fig. 110). As was found in field collections, larvae 14-18 mm were the dominant group in entrainment samples. During 26-27 June, most smelt larvae entrained were 16-24 mm. This susceptibility of relatively large smelt larvae



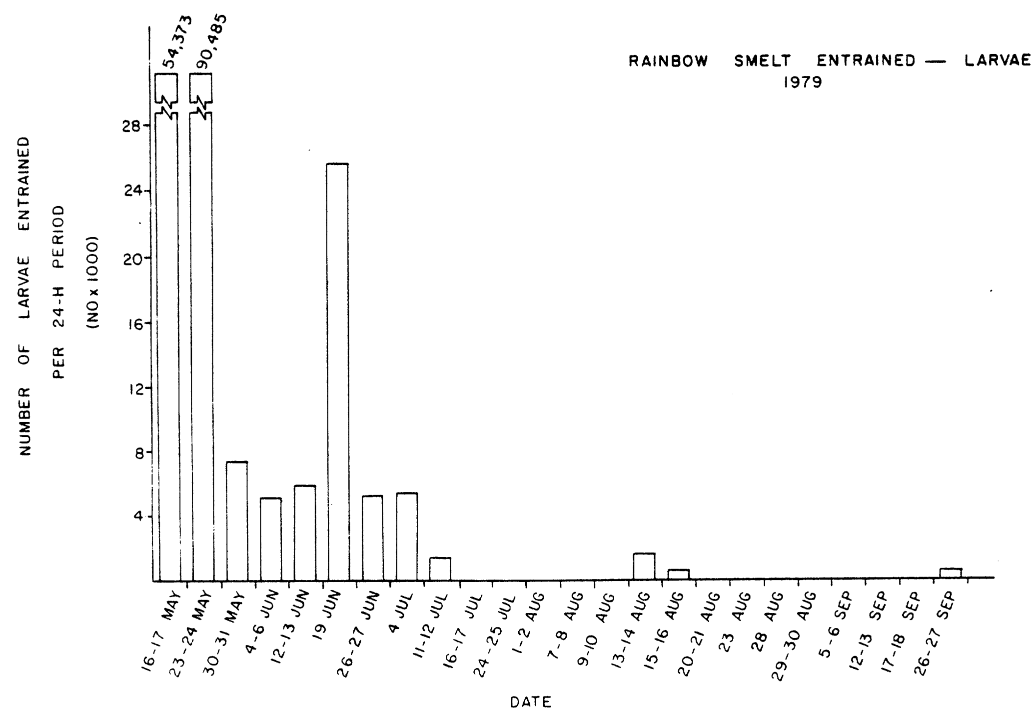


Fig. 117. Total number of rainbow smelt larvae entrained during a 24-h period projected from densities observed in the 16 samples collected weekly at the J.H. Campbell Plant, eastern Lake Michigan, 1978 and 1979.

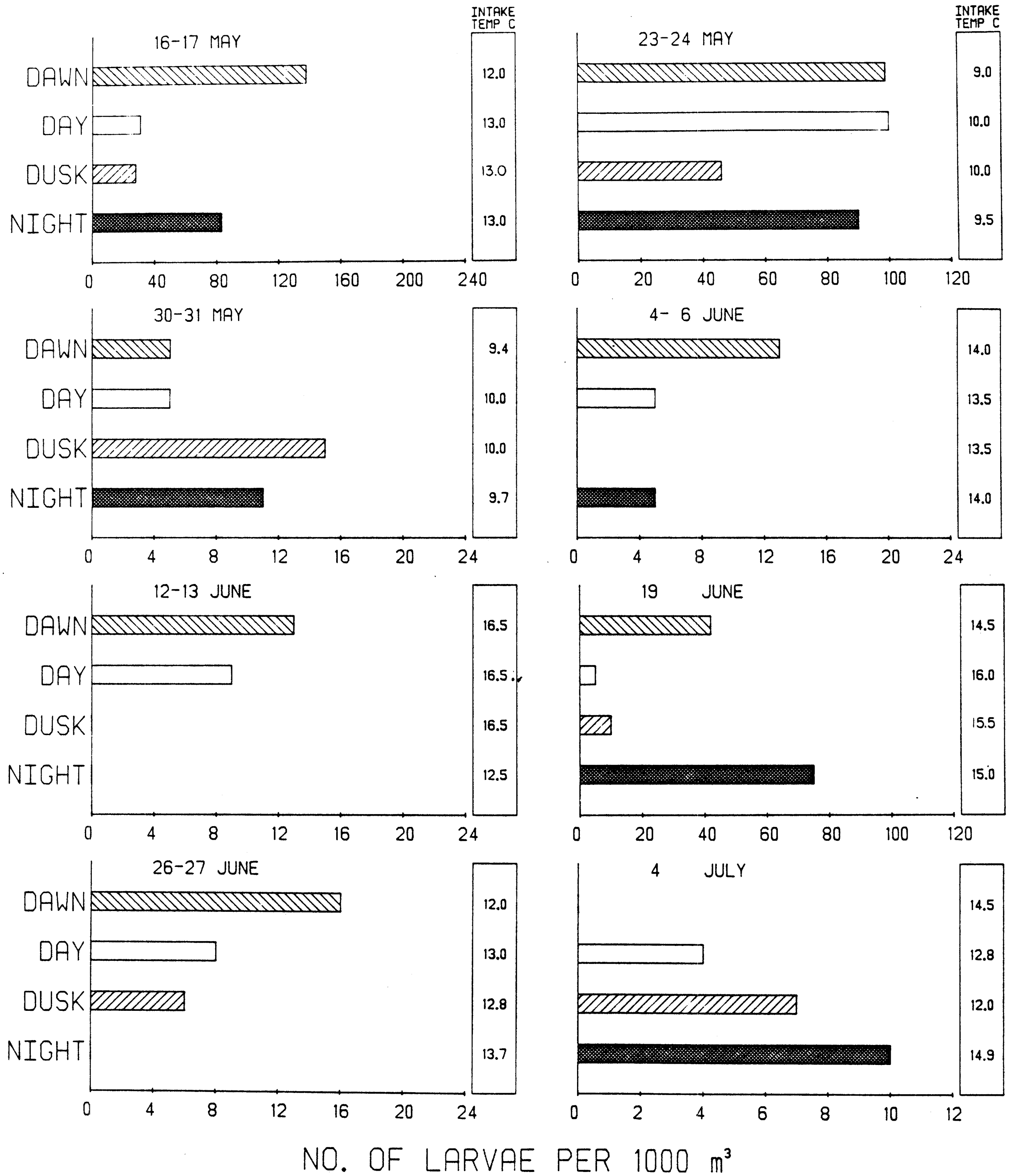


Fig. 118. Density of rainbow smelt larvae (no./1000 m^3) in weekly dawn, day, dusk and night entrainment samples at the J.H. Campbell Plant, eastern Lake Michigan 1979.

to entrainment was also observed in 1978. During June smelt larvae were entrained most frequently during dawn (Fig. 118). Low numbers of yearling smelt (155 mm) were also entrained during June.

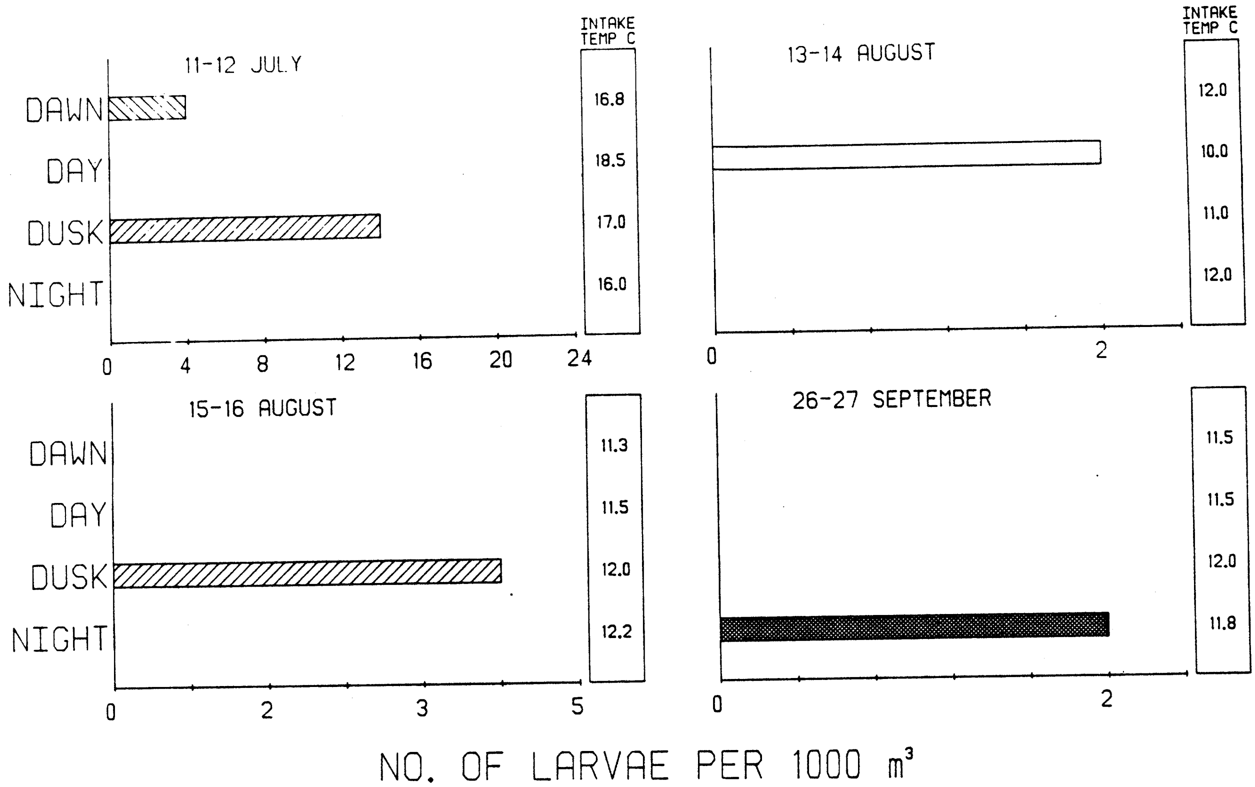
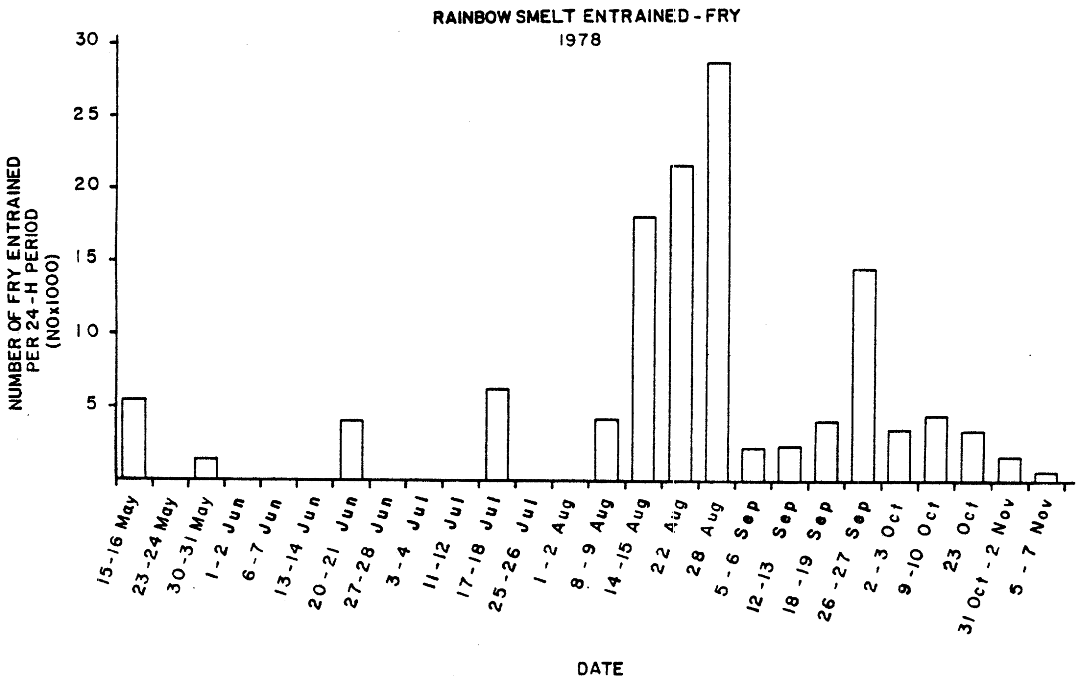


Fig. 118. Continued.

July--Entrainment of smelt larvae continued to decline in July. Entrainment losses were approximately 5469 larvae/24 h during 3-4 July and 1458 larvae/24 h during 11-12 July (Fig. 117). Only larger larvae (8.5-23 mm) were entrained during July (Fig. 110). Newly hatched larvae we observed in Lake Michigan and Pigeon Lake during 17-19 July did not occur in entrainment samples probably because of their low abundance in inshore water. A few YOY smelt (35-43 mm) also occurred in entrainment samples during July.

August--Low numbers of smelt larvae were entrained during August 1977 and 1978. No smelt larvae were collected in August 1979 entrainment samples. Most YOY smelt probably reached fry size (>25.4 mm) by this time.

Smelt fry (26-60 mm) were entrained in substantial numbers during August 1979. The rate of fry entrainment increased rapidly from 3500 fry/24 h during 1-2 August to a peak of 163,774 fry/24 h during 15-16 August. Density of fry entrainment abruptly declined to 61,585 fry/24 h during August 20-21 to 3000 fry/24 h during 29-30 August (Fig. 119). A similar pattern of entrainment was observed in August 1977 (Jude et al. 1978) and 1978 (Fig. 119). As was found



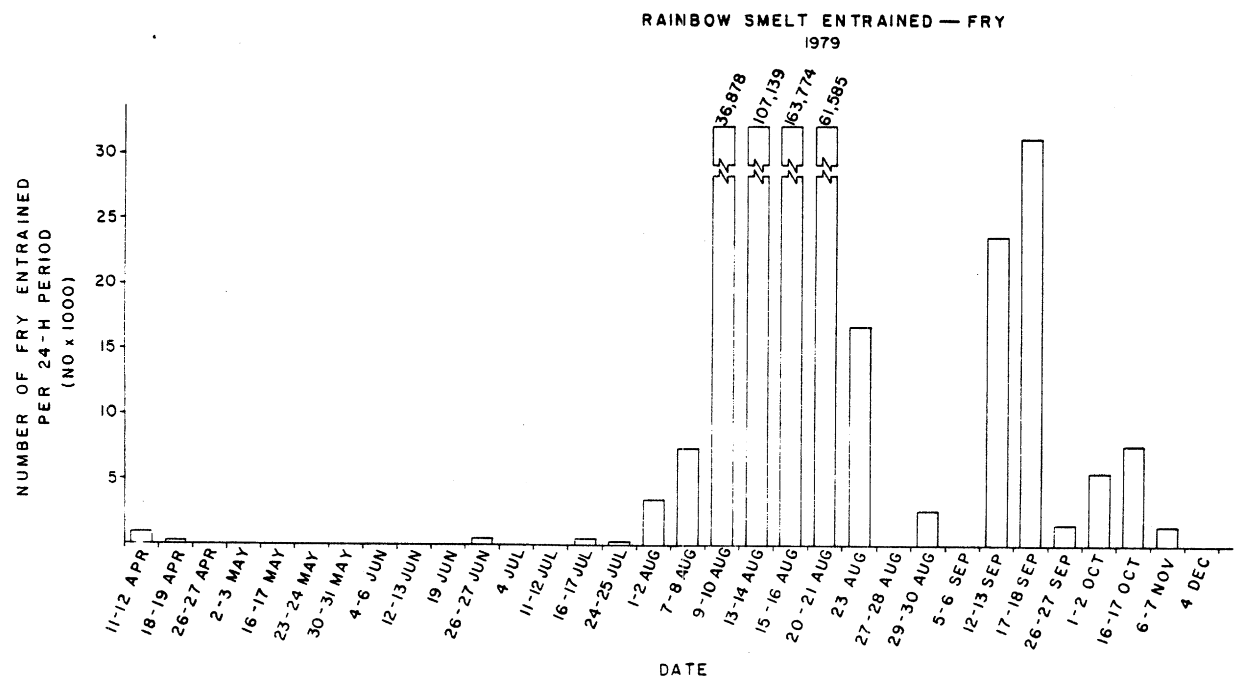


Fig. 119. Total number of rainbow smelt fry entrained during a 24-h period projected from densities observed in the 16 samples collected weekly at the J.H. Campbell Plant, eastern Lake Michigan 1978 and 1979.

during the previous 2 yr, high entrainment of YOY smelt coincided with high catches of this size group in plankton nets, larvae sleds and trawls in Lake Michigan. During 1977-1979 highest entrainment of smelt fry was found in 1979 and lowest in 1978. These entrainment levels reflected the relative year class strength of smelt which was highest in 1979 and lowest in 1978 (see ADULT AND JUVENILE FISH-Rainbow Smelt). Smelt fry were found in entrainment samples collected during all diel periods. Most fry were entrained at night (Appendix 16). A small number of YOY smelt retained on the traveling screens were found in impingement samples (see ADULT AND JUVENILE FISH-Rainbow Smelt). Yearling smelt (82 mm) occurred in low numbers in August entrainment samples.

September, October, November--Entrainment of YOY smelt on 12-13 September (25,000 fry/24 h) increased substantially compared to the level observed during 29-30 August (2500 fry/24 h). Fry entrainment reached a peak (30,000 fry/24 h) during 17-18 September and declined toward the end of the month. Low fry entrainment during September compared to August was due to the offshore migration of YOY smelt during September. Smelt fry continued to be occasionally entrained at a rate of 2000 to 7500 fry/24 h in October and November (Fig. 119).

Gizzard Shad

Introduction--

Gizzard shad larvae are difficult to distinguish from the larvae of other clupeids. In the vicinity of the Campbell Plant, they are easily confused with alewife larvae, particularly after the yolk has been absorbed, yet prior to development of fin ray elements. During 1979 the number of adult and juvenile alewife collected far outnumbered gizzard shad, with only 37 adult gizzard shad captured in field gear. These adults were collected from April to December, but most commonly in October.

Seasonal Distribution--

Of the 73 larvae identified as gizzard shad, most came from field samples. Gizzard shad larvae were identified from Pigeon Lake, the intake canal (station Z) and entrainment samples. Most were collected during May and June, however, a few small larvae were observed in August and September (Appendixes 10-13).

Seven gizzard shad larvae were caught in Pigeon Lake. All were collected at open water stations M (influenced by Lake Michigan) or X (undisturbed Pigeon Lake). They were caught from May to August and averaged 4.5 mm. A single 3.5-mm larva was also recovered in a station Z (intake canal) tow during May. Densities ranged from 30 to 124/1000 m³ (Appendixes 10 and 11).

Gizzard shad larvae were most abundant in Lake Michigan. During May, 34 larvae were collected, mostly from south transect stations 6 to 12 m (Fig. 120). Densities of gizzard shad larvae in Lake Michigan ranged from 14 to 135/1000 m³. The 27 larvae collected at the south transect in May averaged

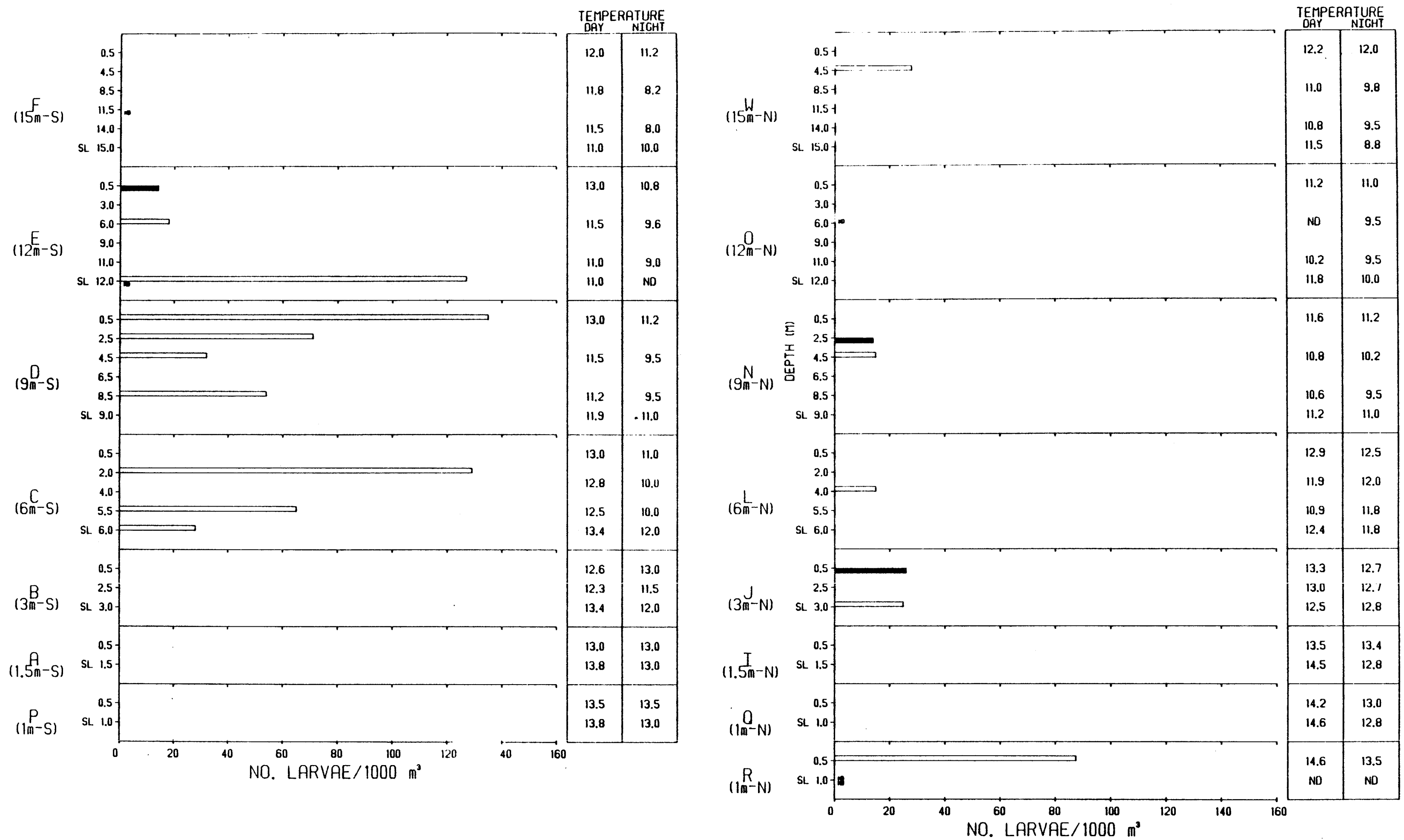


Fig. 120. Density of larval gizzard shad (no./1000 m^3) at Lake Michigan stations near the J.H. Campbell Plant, eastern Lake Michigan, 16-17 May 1979. ☐ = day, ■ = night, SL = sled, ND = no data.

4.8 mm. These larvae may have resulted from gizzard shad spawning during April. Two mature fish were collected at station B (3 m, south) in April (see ADULT AND JUVENILE FISH, Gizzard Shad).

During June, 19 larval gizzard shad were collected from Lake Michigan; all at north transect stations 9 to 15 m. Densities ranged from 15 to 146/1000 m^3. Averaging 5.7 mm, all but one 11.5-mm larva were between 4.0 and 8.0 mm. Gizzard shad larvae were also observed in Lake Michigan catches during early August; these larvae were 7.5 to 14.0 mm. Nine gizzard shad larvae occurred in entrainment samples collected in May, June and September. They averaged 4.8 mm and all but one were small. Entrainment of gizzard shad for all 1979 was estimated to be 37,667 larvae. During 1977 only 10 larvae were identified as gizzard shad; all occurred in entrainment samples.

According to Scott and Crossman (1973) water temperature is an important factor in spawning and survival of gizzard shad. Larvae, believed to be gizzard shad, were always caught in our study area in relatively warm water between 10.0 and 18.5 C. Those larvae which were collected during August in Lake Michigan and those from entrainment samples in September could have resulted from spawning all summer in the discharge canal. Supplemental larvae tows during mid-May revealed the presence of small gizzard shad larvae within the discharge canal. Gizzard shad were the second-most abundant species observed in impingement samples, usually caught during winter months once the grate between the intake and the discharge was opened (ADULT AND JUVENILE FISH, Gizzard Shad).

As was stated earlier, gizzard shad larvae are not easily distinguished from those of alewife, particularly after the yolk is absorbed at about 6 mm. Most larvae collected in the vicinity of the Campbell Plant which were believed to be gizzard shad ranged from 3.5 to 5.5 mm. Few individuals larger than 10 mm were thought to be shad and no fry have been collected during the 3-yr preoperational study. The smallest fish collected in adult gear or observed in impingement samples in 1979 was about 40 mm.

Trout-perch

Trout-perch have been a major adult species in the study area for 3 yr; however, until 1979 very few larval trout-perch had been collected. In 1977 four larvae were caught, three were obtained from Lake Michigan sled tows and one larva occurred in an entrainment sample. Four trout-perch were also collected in 1978. Two of these larvae occurred in entrainment samples and two came from Lake Michigan. In Lake Michigan larvae were collected during July, August and September; they ranged from 6 to 15 mm. Larval trout-perch (5.4-6.0 mm) occurred in May and July entrainment samples.

Larvae of this demersal species again occurred in both entrainment and Lake Michigan samples during 1979, yet were much more abundant than in previous years. Sixteen larvae occurred in entrainment samples resulting in an estimated entrainment total of 86,529 larvae for the year. These larvae

occurred in April, May, June, August and September samples. Eleven trout-perch "fry" (> 25.4 mm) were also collected incidentally in plankton net and sled tows during 1979.

Eleven trout-perch larvae were captured in Lake Michigan during April, August and September. Density of trout-perch larvae varied from 20 to 202/1000 m^3 (Appendixes 10 and 11). During April two small larvae, 6.0 to 7.0 mm, were collected at south transect beach and 9-m stations. Four trout-perch were caught in August, a 5.7-mm larva in a sled tow at station E (12 m, south) and three (7.5, 8.0 and 12.8 mm) in a sled tow at station L (6 m, north). In September five trout-perch larvae were recovered in sled tows, one at the south transect 9-m station and one at each north transect 3-, 9-, 12- and 15-m station.

According to Jude et al. (1979b) and Fish (1932), newly hatched trout-perch are 5.5 to 6.0 mm. The prolonged, 4- to 5-mo period in which these recently hatched larvae occurred in our catches may indicate that adult trout-perch spawn all summer in southeastern Lake Michigan (Jude et al. 1979a). Growth patterns were evident in Lake Michigan-caught specimens. April larvae were 6.0 to 7.0 mm, August larvae 5.7 to 12.8 mm and those caught in September 6.8 to 19.0 mm (Fig. 121). Larvae recovered in entrainment samples were small (4.4 to 7.8 mm) from April to August. Only in September were substantially large specimens (9.5 to 10.0 mm) caught (Fig. 121). Trout-perch fry were collected in June and July (Appendix 15). Four 32- to 49-mm individuals occurred in north transect sled tows conducted at the 1.5- and 6-m contours. In July, four more trout-perch fry (40 to 57 mm) were recovered in sled tows at 6- and 12-m north transect stations. A 55-mm trout-perch fry also occurred in a July entrainment sample (Appendix 15).

The fact that most trout-perch larvae and fry were recovered from north transect sled tows may indicate that these fish utilize as cover and spawning substrate the rocky area created by construction of intake and discharge facilities. Perhaps food organisms are also made more available due to increased digging and dredging. Of greater likelihood, is that lower water clarity during sampling (see FISH EGGS AND LARVAE, Yellow Perch) may decrease the ability of these fish to avoid our gear. Secchi disc readings were low in early August, 0.5 m at station L (6 m, north) where three larvae were collected in a sled tow; whereas, the reading was 2.5 m at station C (6 m, south) where no larval trout-perch were found. Differences in water clarity were much more dramatic during catches of fry trout-perch.

Fourhorn Sculpin

Even though adult fourhorn sculpins were never collected during the 3-yr period of preoperational study, larval fourhorn sculpins were observed in early spring Lake Michigan and entrainment samples. Spawning is thought to take place in winter in Lake Michigan, with larvae widely distributed in the spring. Sampling efforts did not commence until June in 1977, causing us to miss their major period of abundance. Therefore, occurrence of these larvae within the study area was not documented until 1978 and 1979.

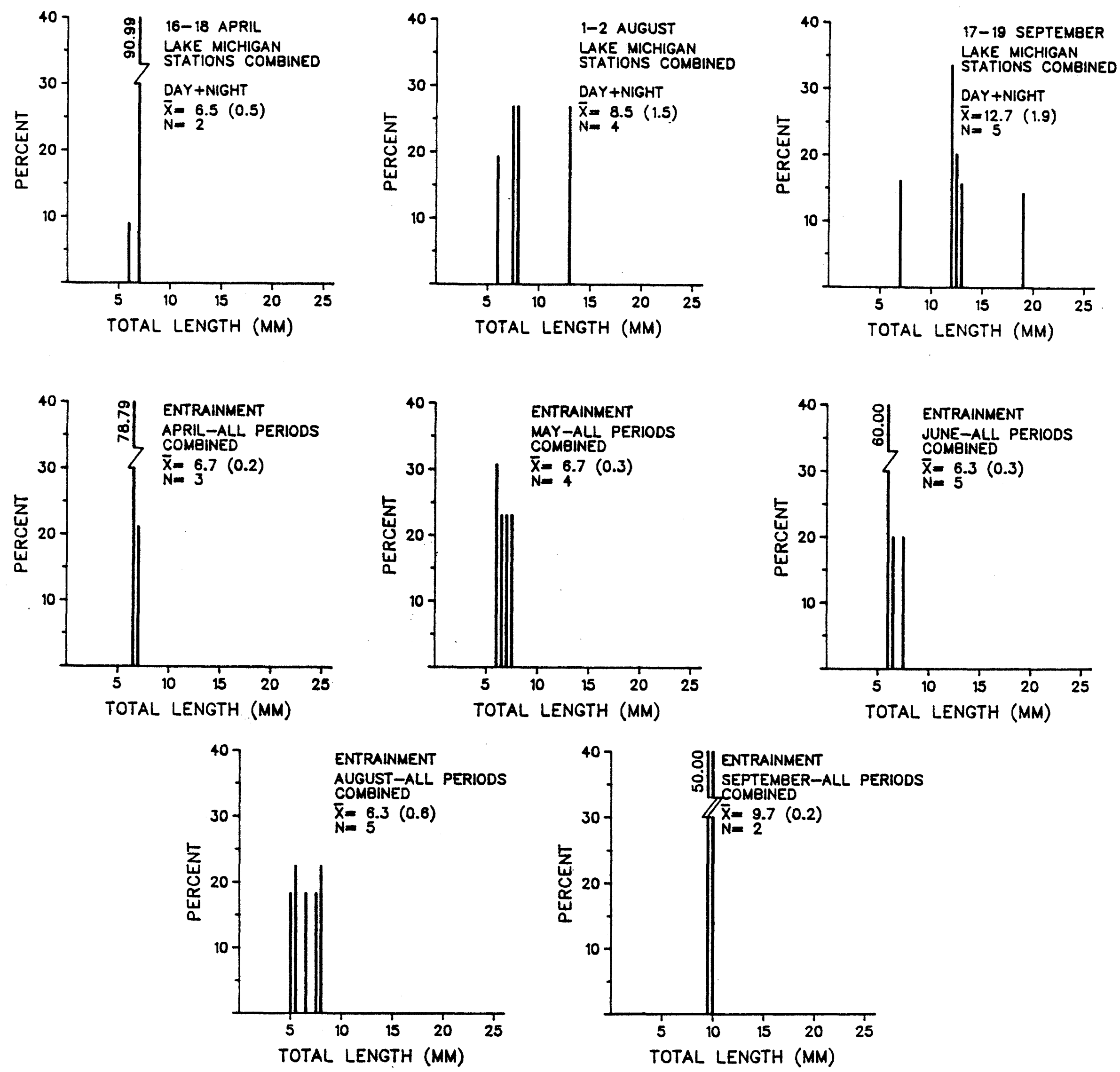


Fig. 121. Length-frequency histograms for larval trout-perch observed in entrainment and field samples from Lake Michigan during 1979 near the J.H. Campbell Plant, eastern Lake Michigan. $\overline{X}$ = mean, N = total number of larvae, standard error is given in parentheses.

In 1978 fourhorn sculpin larvae occurred in densities of 4 to 20/1000 m^3 during the first entrainment sampling period in February and in the second and third weeks of sampling during April. An estimated 227,000 larvae were entrained for that year. Larval fourhorn sculpins were also observed in Lake Michigan pelagic and sled tow samples at 6- to 15-m stations. Larval densities were low, ranging from 11 to 71/1000 m^3 (Jude et al. 1979a).

Fourhorn sculpin larvae occurred more frequently in 1979 entrainment samples; however, densities were low (1 to 7/1000 m^3, Appendix 14) and the overall estimated entrainment rate was 166,000 larvae (see YEARLY ENTRAINMENT SUMMARY) which was less than that observed in 1978. These larvae were observed in samples taken the last week of February, the first, third and fourth weeks of March, the second and third weeks of April and the last week in May (Appendix 14).

Field sampling revealed the presence of this species of larvae again at 6 to 15 m in Lake Michigan during April, May and July. Densities were low (14-22/1000 m^3) (Appendixes 10 and 11). This species obviously prefers cold water and their presence in the area in July was due to an upwelling which took place during this month (Fig. 68). Fourhorn sculpin larvae were recovered in Lake Michigan from water 3.5 to 7.0 C in 1978 and 2.3 to 10.2 C in 1979.

Operation of the plant's offshore intake and discharge system should have little effect on this species. Adults are not known to frequent the area and a few larvae are found in the area only during late winter, early spring months. Spawning by this demersal species is believed to take place in open water of Lake Michigan in late winter and hatching sometime in early spring (Westin 1969).

Slimy Sculpin

Although adult slimy sculpins are seasonally abundant in the area of the Campbell Plant, occurrences of the larvae have been relatively rare. Spawning in the area of the plant probably occurs in April-May. One mass of sculpin eggs was taken from a log which was trawled at station E (12 m, south) in May, at a water temperature of 11.2 C. Although the reproductive biology of slimy sculpins in Lake Michigan is poorly known, it is likely that most spawnings occur on the undersides of rocks or other available submerged objects.

Larval slimy sculpins first occurred in Lake Michigan samples during early July. At this time, three larvae (9-14 mm) were found at the 9- and 12-m contours resulting in low (17-42 larvae/1000 m^3) densities. Water temperatures at times of capture ranged from 5 to 8 C. Absence of smaller larvae from our collections is probably due to the tendency of recently hatched larvae to remain in or near their protected nesting sites until yolk absorption. By 9 mm, larval sculpins have diminished yolk sacs and are actively feeding (Heufelder and Auer 1980). Capture of larvae at the 3-m depth stratum at station O (12 m, north) in early July suggests that larvae may not be as demersal as adults.

Late July sampling indicated densities of 13-130 larvae/1000 m³ were present at deeper stations (12 and 15 m) in Lake Michigan. Temperatures at times of capture ranged from 3.0 to 6.0 C. Size range of the seven larvae caught was 8.5-15 mm. Absence of slimy sculpin larvae from shallower depths may be due to avoidance of higher water temperatures which existed there.

August marked the final occurrence of slimy sculpin larvae in our samples. At this time, a size range similar to that observed in July (8.5-16.5 mm) was noted. Seven larvae were caught at the 12- and 15-m depths at water temperatures 6.8 to 7.7 C resulting in larval densities of 15-167 larvae/1000 m³.

It is significant that all slimy sculpin caught at Lake Michigan stations were taken at night. Due to the precocious nature of the larvae upon hatching, it is possible that net avoidance may be a major factor contributing to the absence of larval sculpins from day samples. Another possibility is that larvae remain in protected areas during light hours, and disperse from these areas at night, thus making them more susceptible to our gear.

Throughout the year, only one slimy sculpin (8.0 mm) was observed in entrainment samples (13 June) at the Campbell Plant. It is likely that the present intake of Units 1 and 2 only occasionally entrains slimy sculpin larvae due to its shallow (6 m) depth of water withdrawal. Initial indications are that slimy sculpin larvae are generally distributed in deeper water.

Johnny Darter and *Etheostoma* spp.

During the 3-yr preoperational study adult johnny darters were a major species in the study area; however, johnny darter larvae have rarely been collected. Since the bottom-dwelling johnny darter spawns under rocks, logs and other objects (Winn 1958) and the young are guarded by adults, our gear may be ineffective in sampling the young of this species.

Twelve darter larvae were collected in 1977. Eleven from Pigeon Lake in early June, and one from an entrainment sample in July. Eight were identified as johnny darter larvae and four simply as *Etheostoma* spp. In 1978 only two johnny darter larvae were encountered. One larvae was caught in Lake Michigan during August and one was entrained during June.

Larval johnny darters were much more frequent in our 1979 catch and were equally abundant in Lake Michigan, Pigeon Lake, intake canal and entrainment samples. Ten larvae (6-24 mm) were captured during August and September, all at night (Appendixes 10 and 11). All but one came from sled samples in Lake Michigan. Densities ranged from 36 to 187/1000 m³ (Appendixes 10 and 11). Five johnny darter larvae were observed in Pigeon Lake samples and one in an intake canal, station Z sample (Appendixes 12 and 14). These larvae, 4.6 to 22.5 mm were collected from May to July. Densities in Pigeon Lake were higher than those observed in Lake Michigan, ranging from 46/1000 m³ at station Z to

533/1000 m^3 at station S. Johnny darter larvae were also entrained from June to September. The seven larvae collected ranged from 5.5 to 6.7 mm. Estimated entrainment of this species for 1979 was 27,374 larvae.

Johnny darter fry were also collected from May to August 1979. Five fry, 31.5 to 41.0 mm, were removed from Lake Michigan sled tow samples collected from May to July. Johnny darter larvae and fry were equally distributed between both transects from the beach zone to 12 m. A single 26.5-mm fry was encountered at beach station S in Pigeon Lake during August (Appendix 15). Except for the fish collected at station S, all "fry" were probably yearlings.

Unidentified Catostomidae

Larval suckers were collected for the first time in the study area during 1978. Although only four were recovered in field samples, 29 occurred in entrainment samples during May and June. Different size groups appeared and it was hypothesized that larvae of both the longnose and white sucker were present (Jude et al. 1979a). According to Scott and Crossman (1973), longnose suckers spawn sometime from mid-April to mid-May, before white suckers.

In 1979 two size groups of sucker larvae were present. Seven larval suckers were obtained in entrainment samples during May (Appendix 13) and of these, three were small 7.5- to 8.1-mm larvae probably white suckers, and four were larger 14.0- to 20.0-mm larvae probably longnose suckers. Entrainment of unidentified sucker larvae was estimated to have been 19,100 larvae for 1979; all were collected in April and May (see YEARLY ENTRAINMENT SUMMARY). One other larval sucker was caught in 1979, a 22.0-mm specimen from beach station S (influenced by Lake Michigan) also during May. Density of sucker larvae in this area was calculated to be 111/1000 m^3. Although catch of both longnose and white suckers increased from 1978 to 1979, and these species were abundant in the area, their spawning habits are still not well understood.

Burbot

No larval burbot were collected during 1977; however, field and entrainment sampling efforts did not commence until June and July respectively (Jude et al. 1978). In 1978 larval burbot were numerous in entrainment and Lake Michigan plankton samples collected during April, May and June (Jude et al. 1979a). Catch of burbot larvae in 1979 sharply contrasts with that of 1978. Larval burbot were entrained only once and occurred in Lake Michigan samples in sparse numbers during May and June.

Seasonal Distribution--

April--In 1978, larval burbot were most abundant in the study area during April. In 1979, no burbot larvae were recovered from April samples. A few larvae occurred in Lake Michigan samples in May 1979, however, most larval burbot were observed in June.

May--Larval burbot were observed in entrainment samples only once in 1979. A single larva was found in a dawn entrainment sample the first week of May. Burbot larvae also occurred at south transect stations D (9 m, south) and F (15 m, south). At the north transect, burbot larvae were seen at stations O (12 m, north) and W (15 m, north). All larvae collected in May ranged from 3.8 to 4.5 mm. They occurred in water 9.5 to 11.8 C and ranged in density from 16 to 37/1000 m³.

June--Contrary to 1978 findings, no burbot larvae were captured in early June sampling 1979. In late June 1979 burbot larvae were caught at stations A (1.5 m, south), B (3 m, south) and F (15 m, south) at the reference transect, and at stations L (6 m, north), N (9 m, north) and O (12 m, north) along the north transect. These larvae ranged from 3.9 to 7.5 mm, occurred in water 11.4 to 16.0 C and densities varied from 16 to 48/1000 m³.

Other Considerations--

In 1977 two adult burbot were collected in Lake Michigan. In 1978 four adults were obtained from Lake Michigan, but 16 were impinged. From these data, 121 burbot were estimated to have been killed during 1978. In 1979 no adult burbot were observed in field samples, however, 20 fish were impinged. This resulted in an estimated impingement of 126 burbot. Decline in number of both adult and larval burbot from 1978 to 1979 is puzzling. These fish occur so irregularly in the area, a good estimation of population size and distribution has not been possible.

In 1979 larval burbot occurred in low densities primarily in Lake Michigan near the bottom at night at stations 6 m or greater. None were recovered from Pigeon Lake or intake canal (station Z) samples. Only one entrainment sample contained burbot in 1979; whereas, a peak of over 64,000 larvae were estimated to have been entrained during the second week of April 1978. Only 810 burbot larvae were estimated to have been entrained during the entire year in 1979 (see YEARLY ENTRAINMENT SUMMARY).

Water temperature does not appear to be a factor affecting burbot larvae distribution. During April 1978 burbot larvae were most abundant at 6.5 to 8.5 C. In April 1979, although temperatures were similar to those measured in 1978, no larval burbot were recovered.

Unidentified Coregoninae

Larval coregonines have been uncommon in the area throughout the 3-yr preoperational investigations. In field studies, one 13-mm coregonine was collected in 1977 and two larvae (11 and 14.5 mm) were recovered in 1978. These all occurred in plankton net tows at our deepest stations (15 m) on both transects.

During 1979, eight larval coregonines were collected in field samples, five of which occurred in Lake Michigan samples, the remaining three were observed in Pigeon Lake samples. Using Hinrichs (1979) four of these larvae

could be identified as lake whitefish, three as bloater and one specimen was too damaged to be identified. The four whitefish were all taken during April and May and ranged from 14 to 24 mm. These larvae were observed at station A (1.5 m, south) and Pigeon Lake beach station S (influenced by Lake Michigan). Those larvae believed to be bloater were collected in July and August at Lake Michigan stations N (9 m, north), D (9 m, south) and F (15 m, south). The single damaged coregonine was also taken in July at station J (3 m, north) and is therefore felt to be a bloater larvae. These larvae were smaller, ranging from 11.0 to 13.0 mm.

A "fry" was incidentally caught in a plankton net tow at station W (15 m, north) as well. This 54.5-mm individual was taken at night in mid-September (Appendix 15) and was identified as a bloater.

During 1978 three coregoninae larvae were entrained. These 11.2- to 14.2-mm fish occurred in April and May samples. In 1979 one 15-mm coregoninae larvae believed to be a lake whitefish, was entrained during April. From these data, 607 unidentified coregoninae larvae were estimated to have been entrained for all 1979 (see YEARLY ENTRAINMENT SUMMARY).

The theory that two different species of coregonid larvae are now present in the study area is supported by the size of the larvae and month of collection. Lake whitefish usually spawn in the fall (November-December), eggs slowly incubating until early spring. The rather large coregonine larvae in the study area were seen during April and May. This species usually spawns in shallow water and may have even utilized the jetty area, therefore resulting in the observation of larvae in Pigeon Lake and entrainment samples.

Bloaters spawn in early spring (February-March) and eggs of this species are not expected to hatch until after lake whitefish eggs hatch. The smaller larvae, which were recovered in July and August, are probably those of the bloater.

Ninespine Stickleback

Although ninespine stickleback adults have been a fairly abundant species in our study area, larvae of the species have never been commonly collected. The ninespine stickleback is a demersal fish which constructs a protective nest which is guarded by the male for an extended period (Scott and Crossman 1973). Our gear may therefore be ineffective in sampling the young of this as well as other demersal species (see Trout-perch, Johnny Darter, Sculpins). This species is most abundant in deep water (38-42 fathoms) and those present in our area may just be the fringe of a greater offshore population.

During 1977 nine larval sticklebacks were collected from Pigeon Lake while in 1978 three larval sticklebacks were obtained from Lake Michigan samples and three were observed in entrainment samples. Ninespine stickleback larvae were only captured from Lake Michigan in 1979; all at night and most in sled tows at 6- to 15-m depths (Appendixes 10 and 11). These larvae were

collected from July to September, ranged from 6.7 to 18.0 mm and were equally distributed at the north and south transects. Densities ranged from 12 to $54/1000\ m^3$. No stickleback larvae were entrained in 1979.

Brook Silverside

Although brook silversides have been common in Pigeon Lake over the past 3 yr, larvae of this species were rarely encountered during our sampling efforts. During 1977, 158 adult and 22 larval brook silversides were collected (Jude et al. 1978). In 1978 and 1979, 80 and 87 adult brook silversides respectively, were captured, yet only one larva was observed during this 2-yr period (see ADULT AND JUVENILE FISH Brook Silverside). A 6.0-mm larva was observed in a mid-July entrainment sample (Appendix 14). Brook silversides spawn during late spring and early summer in and around aquatic macrophytes (Scott and Crossman 1973). Most brook silversides captured in our studies have occurred at heavily vegetated stations V (undisturbed Pigeon Lake) and T (undisturbed Pigeon River). Seines are often dragged through vegetation; however, due to clogging problems, plankton nets are not pulled through dense macrophytes, therefore we may miss brook silverside larvae which remain in the protection of vegetation.

Damaged Larvae

Occurrence of damaged larvae in 1977 samples was low and assumed not to bias abundance estimates of known species (Jude et al. 1978). In 1978 the number of damaged larvae increased significantly; however, these specimens were distributed proportionately over all samples such that density of those damaged specimens for any one sample was low (Jude et al. 1979a). During 1979 all damaged larvae were critically examined and based on size, shape, pigmentation pattern and meristic characters, most could be identified to species, thereby reducing the number of unidentified specimens. Nevertheless, more larvae were damaged beyond recognition in 1979 than in 1978. Of the 23,581 larvae collected in 1978, 3.0% or 718 were damaged, while in 1979, 849 or 3.3% of the 25,671 larvae collected were damaged. Approximately 50% of those damaged larvae observed in 1978 occurred in entrainment samples; whereas, over 90% of the damaged larvae in 1979 came from entrainment samples.

Seasonal Distribution-Field Samples--

Only 57 larvae collected in field samples were damaged beyond recognition. These larvae accounted for 0.5% of the 11,743 larvae collected in 1979 field samples from May to September.

May--During May damaged specimens occurred in samples collected at south transect stations from the beach to 9 m. Those at shallow stations 0-3 m were probably larval yellow perch, while those at the 6- and 9-m stations were probably larval rainbow smelt (Appendix 11). A few damaged larvae, again believed to be yellow perch, were caught at open water stations in Pigeon Lake during May (Appendix 12).

<u>June</u>--Damaged larvae were infrequent during both sampling periods in June. A few were taken at stations A (1.5 m, south) and B (3 m, south) on the south transect and some occurred at stations J (3 m, north) and N (9 m, north) at the north transect. Those at stations B and N are believed to be rainbow smelt larvae while those at stations A and J may have been spottail shiner larvae. Damaged larvae also occurred in an intake canal sample during late June, when spottail larvae were abundant (Appendix 13).

<u>July</u>--During both sampling periods in July, occurrence of damaged larvae was more widespread, however, densities were low. At the south transect, damaged larvae occurred at 1.5- to 9-m stations at a time when alewife larvae were abundant. Along the north transect, damaged larvae were more numerous, occurring in samples taken at all stations except I (1.5 m, north) (Fig. 122). Those at beach stations Q (south discharge) and R (north discharge) are probably spottail shiner larvae, while those at the 3- to 15-m stations are believed to be alewives (Appendix 10).

In Pigeon Lake a few damaged specimens were observed in open water station M (influenced by Lake Michigan) samples. At this time, densities of alewife larvae were high (Appendix 12).

<u>August</u>--Once again, a few damaged larvae occurred in south transect samples collected at stations P (south reference), C (6 m, south) and F (15 m, south). Those larvae collected at station P were probably spottail shiners; whereas, those at the other two stations were believed to be alewives (Appendix 11).

As was observed in July, damaged larvae were more abundant in north transect samples (Fig. 122). Specimens occurred in samples collected from the beach to 12 m. Larvae observed in beach tows were probably spottail shiners. Spottail larvae reached densities of 22,801 to 32,048/1000 m^3 at the beach and 1.5-m stations during early August (Appendix 10). Damaged larvae collected from 6 to 12 m primarily in late August were probably all alewives, since this was the only other species which occurred at these depths (Appendix 11).

Damaged larvae in low abundance also occurred at Pigeon Lake station X (undisturbed Pigeon Lake). At the time of collection alewife, spottail shiner and unidentified <u>Lepomis</u> spp. larvae all occurred in high densities (Appendix 12).

<u>September</u>--A few damaged specimens were observed in September samples collected from 6- and 12-m stations in Lake Michigan. The only other larvae collected at the time were alewives (Appendixes 10 and 11).

Seasonal Distribution-Entrainment Samples--

During 1979, 91% of the damaged larvae occurred in entrainment samples. Most of these occurred in April to July samples at a time when sampling was conducted at Unit 2 because Unit 1 was not in operation. Velocity of

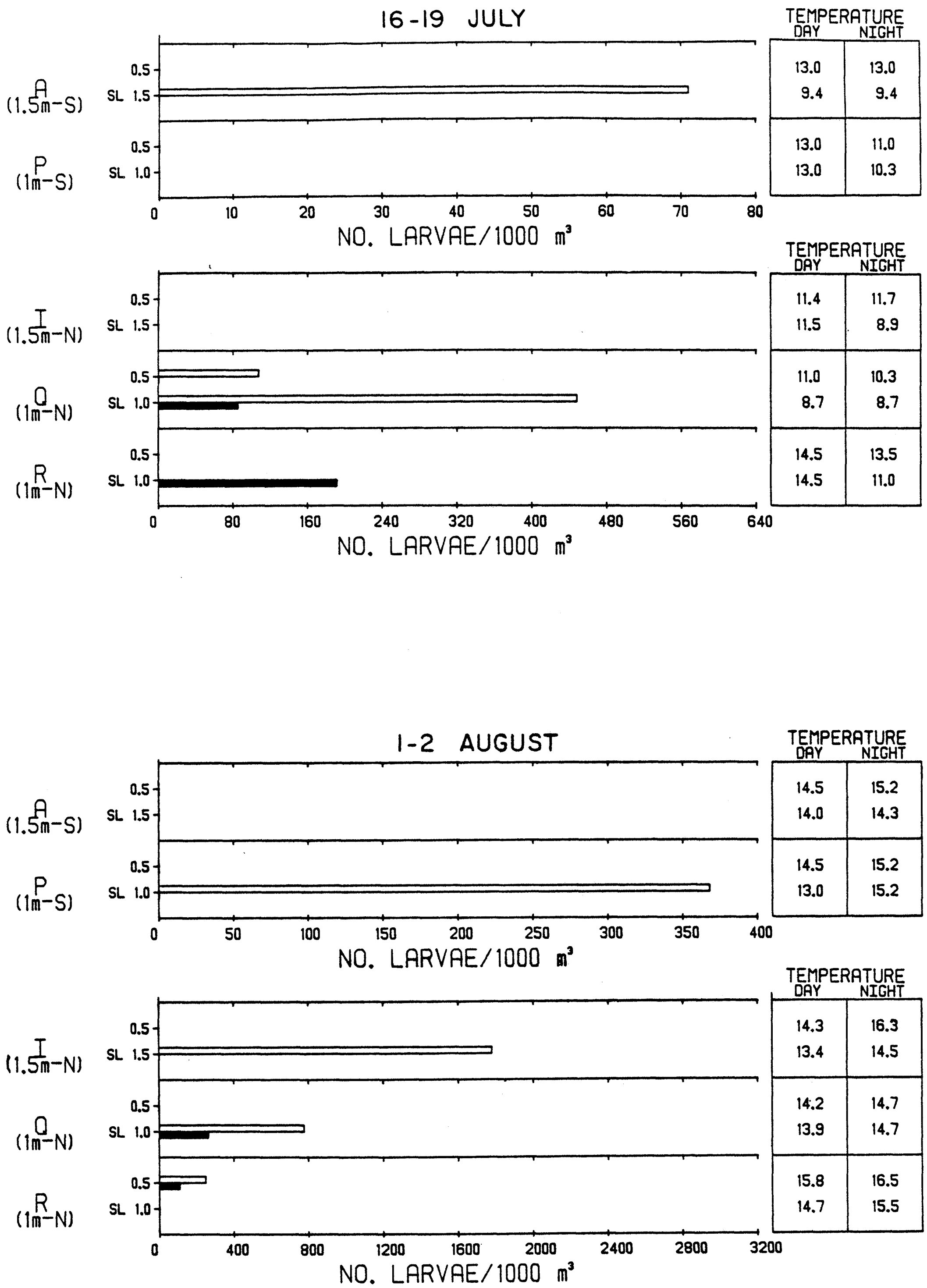


Fig. 122. Density of damaged larvae (no./1000 m^3) during 16-19 July and 1-2 August at Lake Michigan stations near the J.H. Campbell Plant, eastern Lake Michigan. Stations 3-15 m were omitted due to absence of larvae in samples. □ = day, ■ = night, SL = sled.

discharged water at Unit 2 was greater than that observed at Unit 1 and these high velocities combined with sand, plant material and other debris exposed larvae to abrasion particularly when trapped in the collecting net.

April--Only one larva was damaged in April sampling; this specimen was probably a trout-perch, since it was the only species present in the sample at this time (Appendix 14).

May--The greatest number of damaged larvae occurred in May entrainment samples particularly during the third and fourth weeks (Fig. 123). These larvae were believed to be yellow perch since this was the most abundant species in the samples, however, unidentified Pomoxis spp., carp and spottail shiner larvae were also numerous (Appendix 13).

June--Damaged larvae were again observed in all samples taken during this month (Fig. 123). During the first 2 wk, these were probably spottail shiner or carp larvae; whereas, during the last 2 wk, smelt larvae were most numerous. Besides spottail shiner, carp and rainbow smelt, yellow perch, alewife and Pomoxis spp. larvae were also common in these samples (Appendix 14).

July--Prior to the first entrainment period in July, sampling was switched to Unit 1. A dramatic decrease in abundance of damaged larvae was observed throughout the rest of the year even though alewife and spottail abundances were high (Appendix 14). Most damaged larvae were probably these species.

August--Few damaged larvae occurred in August (Fig. 123) even though abundance of alewife and spottail larvae remained high (Appendix 14). The few larvae damaged at this time were probably either spottails or alewives. Damaged fry were also observed in entrainment samples during August. These larger individuals occurred in the fourth and sixth sampling periods (Appendix 16) and were probably either alewife or rainbow smelt fry, both of which occurred in the samples.

September--A few larvae and fry were damaged in September. These were undoubtedly alewives since they were the only species collected at the time (Appendixes 14 and 16).

Summary--

During 1979 damaged specimens accounted for only 0.5% of field-caught larvae; however, they comprised 5.5% of entrained larvae. Abrasion probably causes the greatest damage to larvae. Sand, plant material, as well as the net in which they are collected often cause this abrasion.

Entrainment sampling was conducted at Unit 2 from April to July since Unit 1 was not in operation. Water velocities at the Unit 2 discharge were much greater than those at Unit 1 and therefore account for the increase in damaged larvae at this time, since larvae were forced against the net and other entrained material.

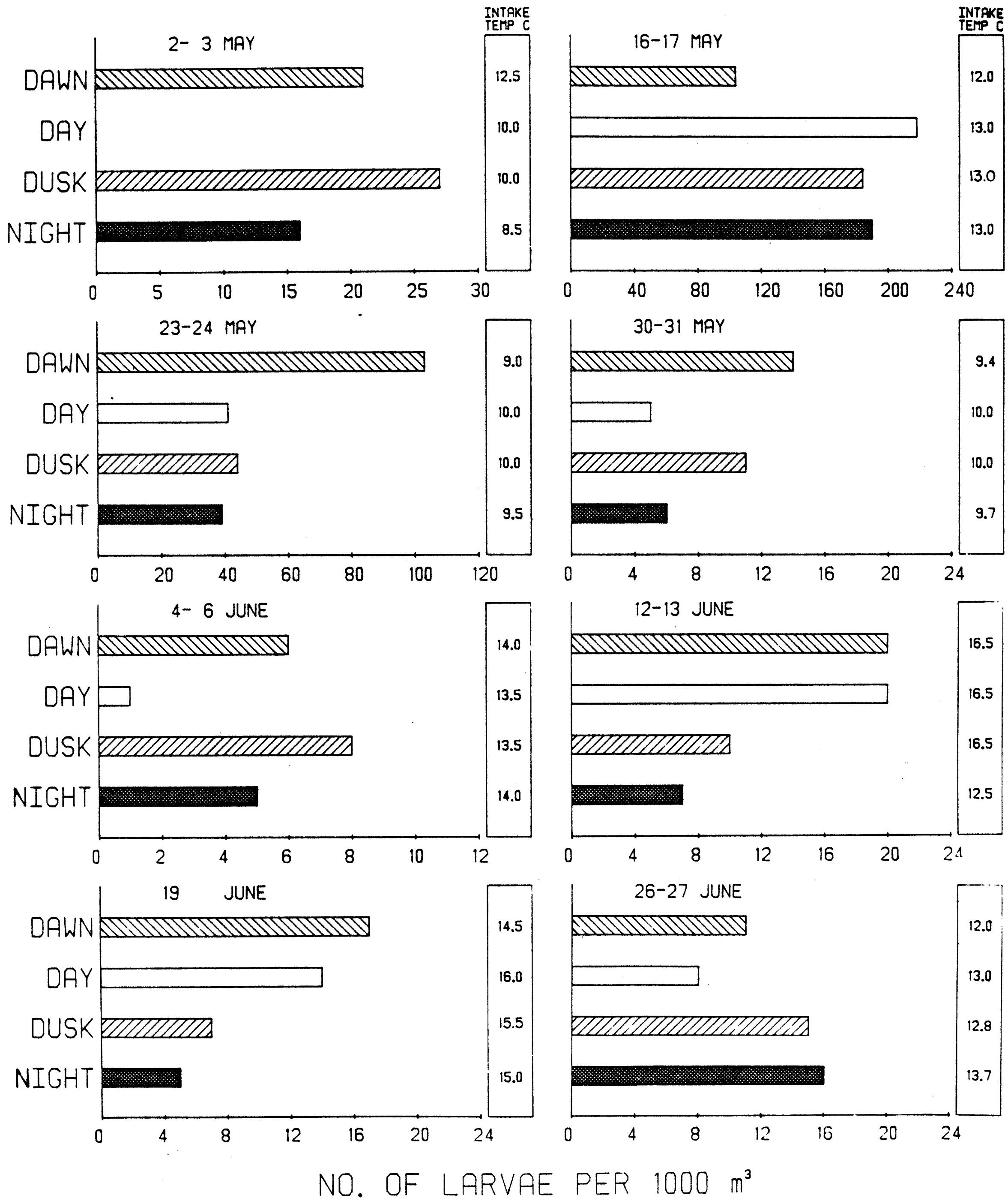
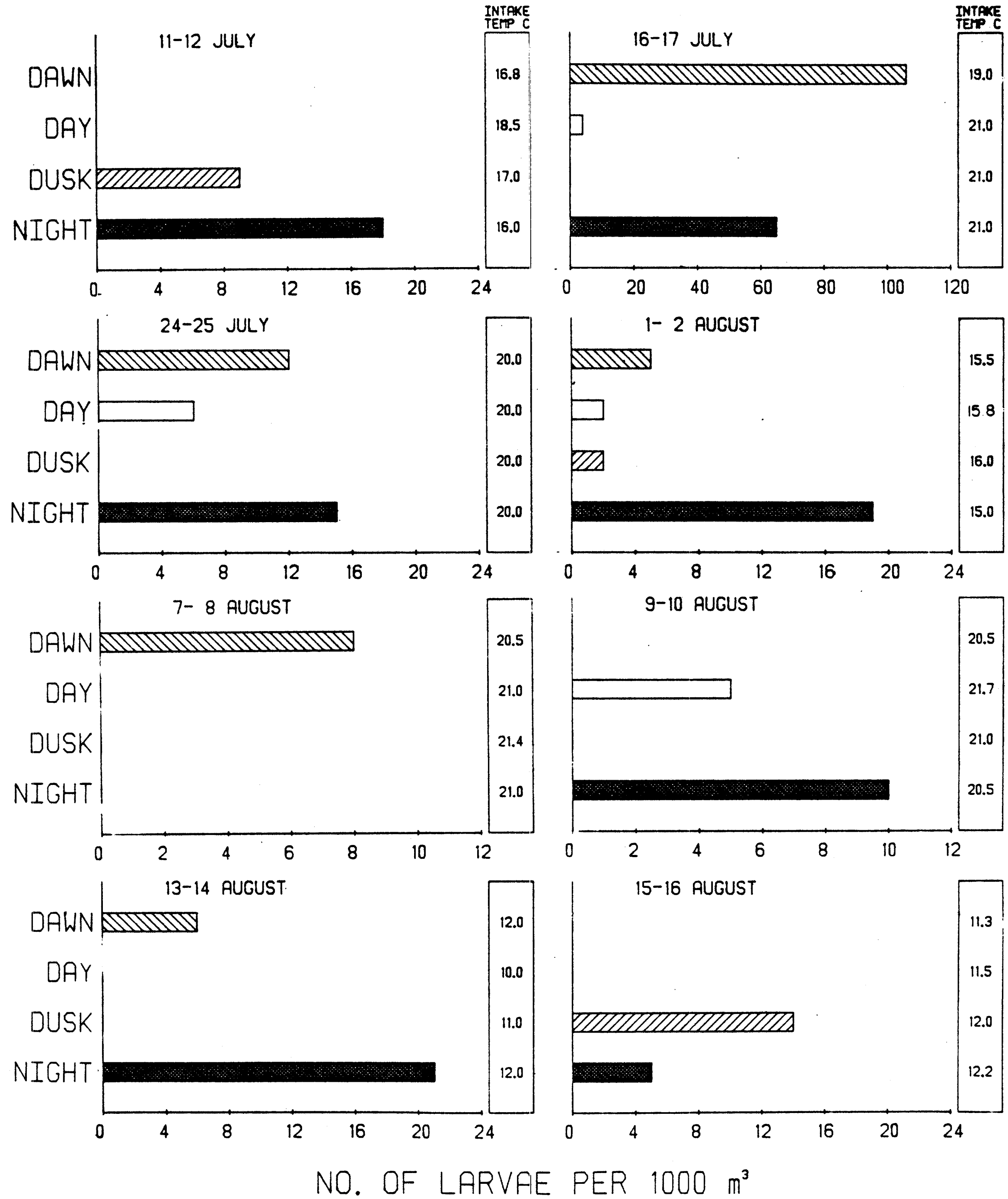


Fig. 123. Density of damaged larvae (no./1000 m^3) in weekly dawn, day, dusk and night entrainment samples at the J.H. Campbell Plant, eastern Lake Michigan 1979.



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In the field, damaged larvae occurred most often at north transect stations Q (south discharge), R (north discharge) and I (1.5 m, north). Densities of damaged specimens were particularly high in July and August, after Unit 1 was again in operation. These larvae may have died or been damaged as they cycled through the cooling system and were subsequently discharged into Lake Michigan. At present, no method is available to detect if larvae are damaged or killed prior to or because of sampling efforts.

Unidentified Pisces

Larvae which were intact, but which could not be identified, were coded as unidentified larvae (XX). In 1977 and 1978 there were three and five of these larvae respectively (Jude et al. 1978, 1979a). Four larvae were not identified during 1979. Three of these occurred in entrainment samples, one in May and two in July (Appendix 14). The specimen from May was collected along with yellow perch larvae which were most abundant, yet carp and unidentified Pomoxis spp. were also prevalent. The two specimens caught in July were observed in an entrainment sample which contained mostly alewives, but a few spottail shiner larvae were captured as well.

The fourth larvae which remained unidentified was a large 25.0-mm fish collected in a tow at Pigeon Lake station S (influenced by Lake Michigan) during May. Yellow perch and emerald shiner larvae were also caught in this sample; however, only the emerald shiner was of comparable size.

Fish Eggs

Introduction--

Abundance of fish eggs in our larval fish samples gives added support to the contention that the area near the Campbell Plant is used extensively as a spawning and nursery area by a variety of fish species. An in-depth analysis of the extent that each species uses the area, as indicated by egg abundance, is precluded, however, by inability to identify many of the eggs. Due to their nondescript appearance, we can only speculate on the identity of many fish eggs found. A knowledge of the reproductive ecology of some species of fish present in the area eliminates their consideration as species contributing eggs sampled. Bluntnose minnows, johnny darters, ninespine sticklebacks, all members of the cottid, centrarchid and ictalurid families, are either nest-building species or species exhibiting parental care of eggs. Unless nesting sites were severely disrupted, we would not expect to collect eggs of these species. In addition, yellow perch and smelt eggs are quite distinct; however, they are rarely collected during our sampling. The species whose eggs would most likely occur in our samples, in consideration of their spawning habit as well as numerical abundance, were alewife, spottail shiner, emerald shiner, burbot and gizzard shad.

Seasonal Distribution--

First occurrence of fish eggs in 1979 samples was in late January when high densities were reported in entrained water (mean density estimated from 16 samples was 1,095 eggs/1000 m^3). Similar high densities continued through early February sampling. These eggs were probably those of burbot. Supplementary gillnetting in December and February in Pigeon Lake documented that burbot with ripe gonads were present in the area, probably for spawning. Egg diameter averaged 1.3 mm and eggs contained the large oil globule characteristic of burbot eggs. Entrainment and field samples from mid-February to mid-April contained no eggs. Later April (18-19) entrainment sampling showed low densities (1-3 eggs/1000 m^3) of eggs in entrained water. It is difficult to speculate on the identity of these eggs, but they could possibly be those of gizzard shad which were reported to spawn during April (see ADULT AND JUVENILE FISH-Gizzard Shad). Coincident with an increased occurrence of eggs in entrainment samples in May (Fig. 124) was an initial occurrence of fish eggs in field samples at Lake Michigan beach station Q (south discharge) and Pigeon Lake beach station S (influenced by Lake Michigan). Low densities (less than 80/1000 m^3) of eggs at these stations were probably due to spottail larvae hatching.

Sampling during early June showed some increase in occurrence of fish eggs, however, their distribution was sporadic and showed no obvious patterns (Fig. 125). The first major occurrence of fish eggs at field stations was observed in late June. At this time, high densities of eggs were observed in Lake Michigan at beach stations, showing decreased densities with increasing depth. It is probable that these eggs were mainly contributed by spottail shiners and alewives. Densities of fish eggs at Pigeon Lake beach stations were also greater in late June compared with early June (Fig. 126). Some eggs at Pigeon Lake stations may have been emerald shiner eggs. Entrainment samples taken coincident with field samples showed parallel increases in egg densities in later (19) June compared with earlier periods.

An upwelling of cold water in early July apparently caused a reduction in spawning activity near the plant, as evidenced by reduced densities of eggs at most Lake Michigan stations (Fig. 125). The decreased densities of fish eggs during early July compared with late June were definitely more pronounced at south compared with north transect stations. This suggests that, although spawning was retarded in Lake Michigan areas unaffected by the onshore thermal discharge, intense spawning was still occurring in the area of the discharge or the discharge canal itself. The species involved, again, were either spottail shiners or alewives. In Pigeon Lake a slight retardation of spawning activity was indicated at beach station S (influenced by Lake Michigan) in early July; however, increased spawning activity was indicated in areas of Pigeon Lake unaffected by Lake Michigan (Fig. 126). Fish egg densities in entrainment samples showed decreases in early July compared with late June, but losses were still maintained at a comparably high level (Fig. 124). Late July sampling indicated that spawning activity had intensified at all Lake Michigan stations (Fig. 125). Eggs showed only a sporadic occurrence at depths greater than 6 m. Again, north transect stations had higher densities of eggs, indicating more intense spawning in the area of the discharge. In

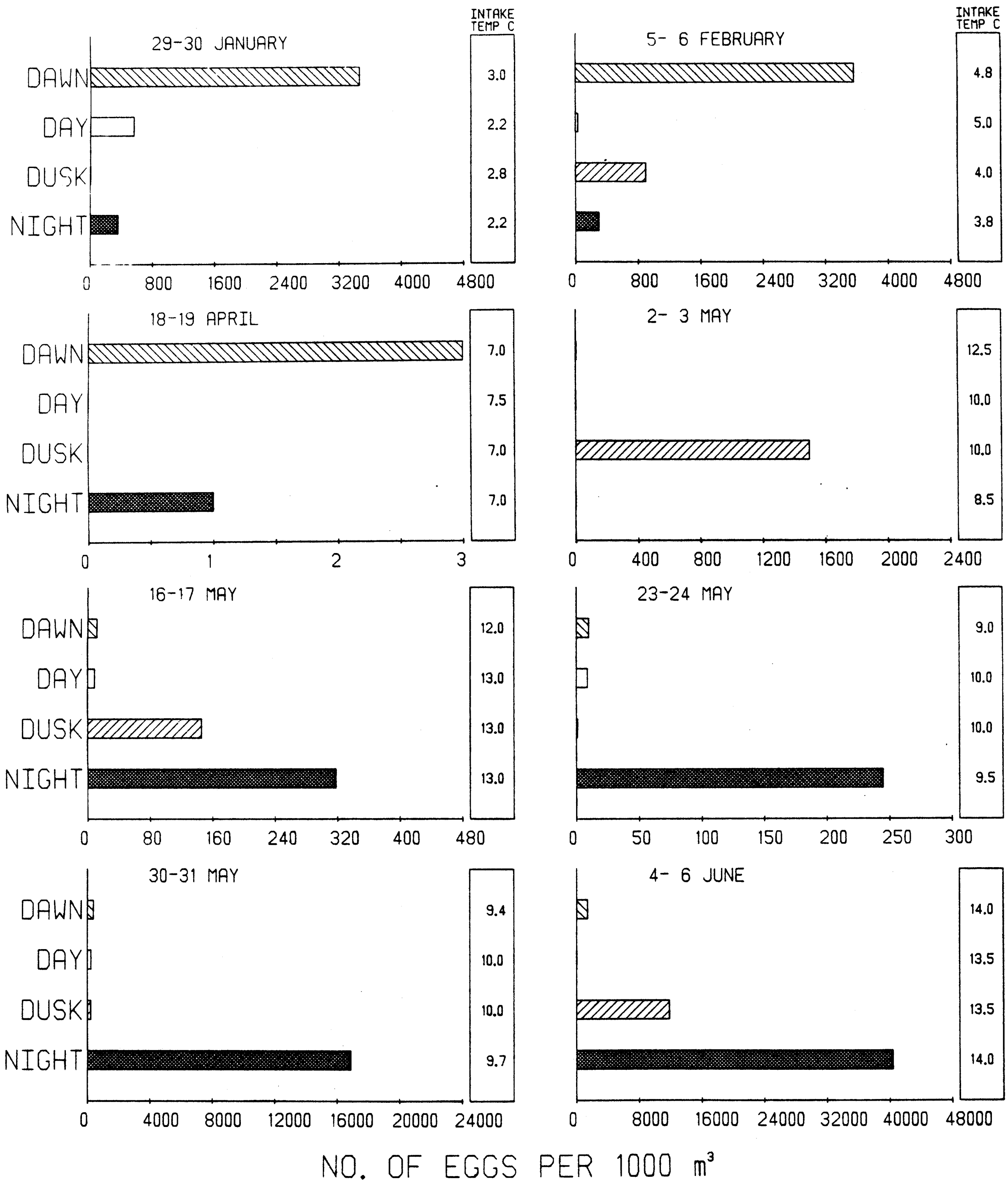
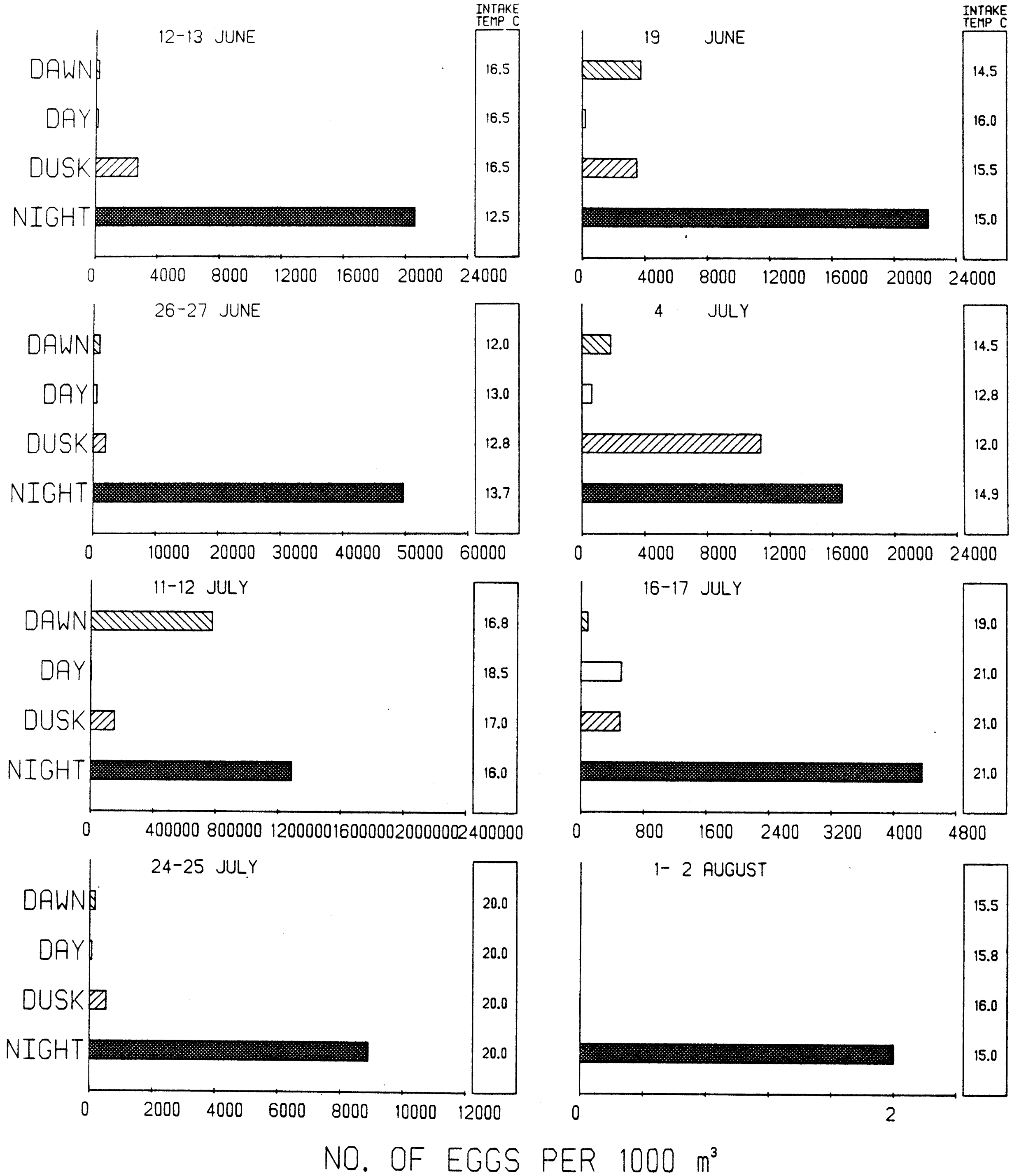


Fig. 124. Density of fish eggs (no./1000 m^3) in weekly dawn, day, dusk and night samples at the J.H. Campbell Plant, eastern Lake Michigan 1979.



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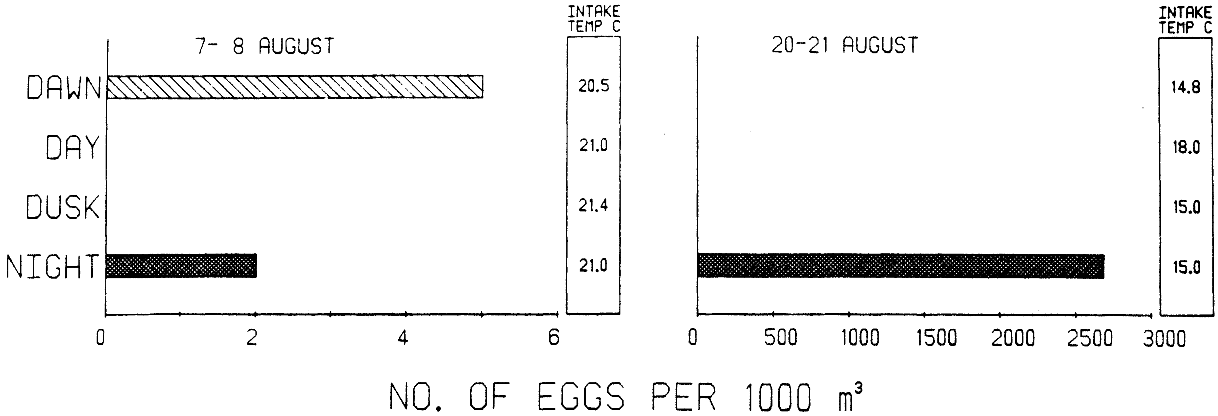

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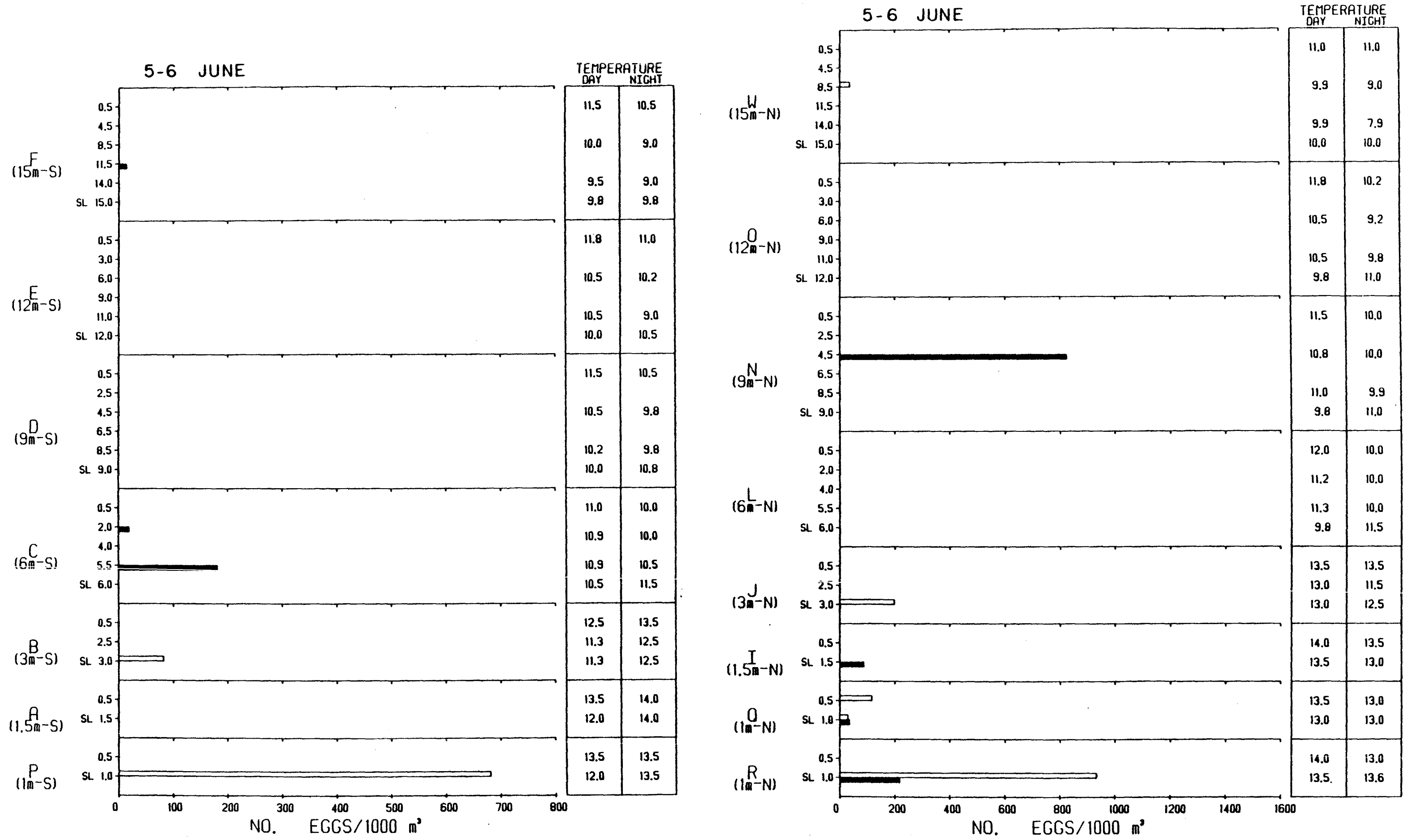
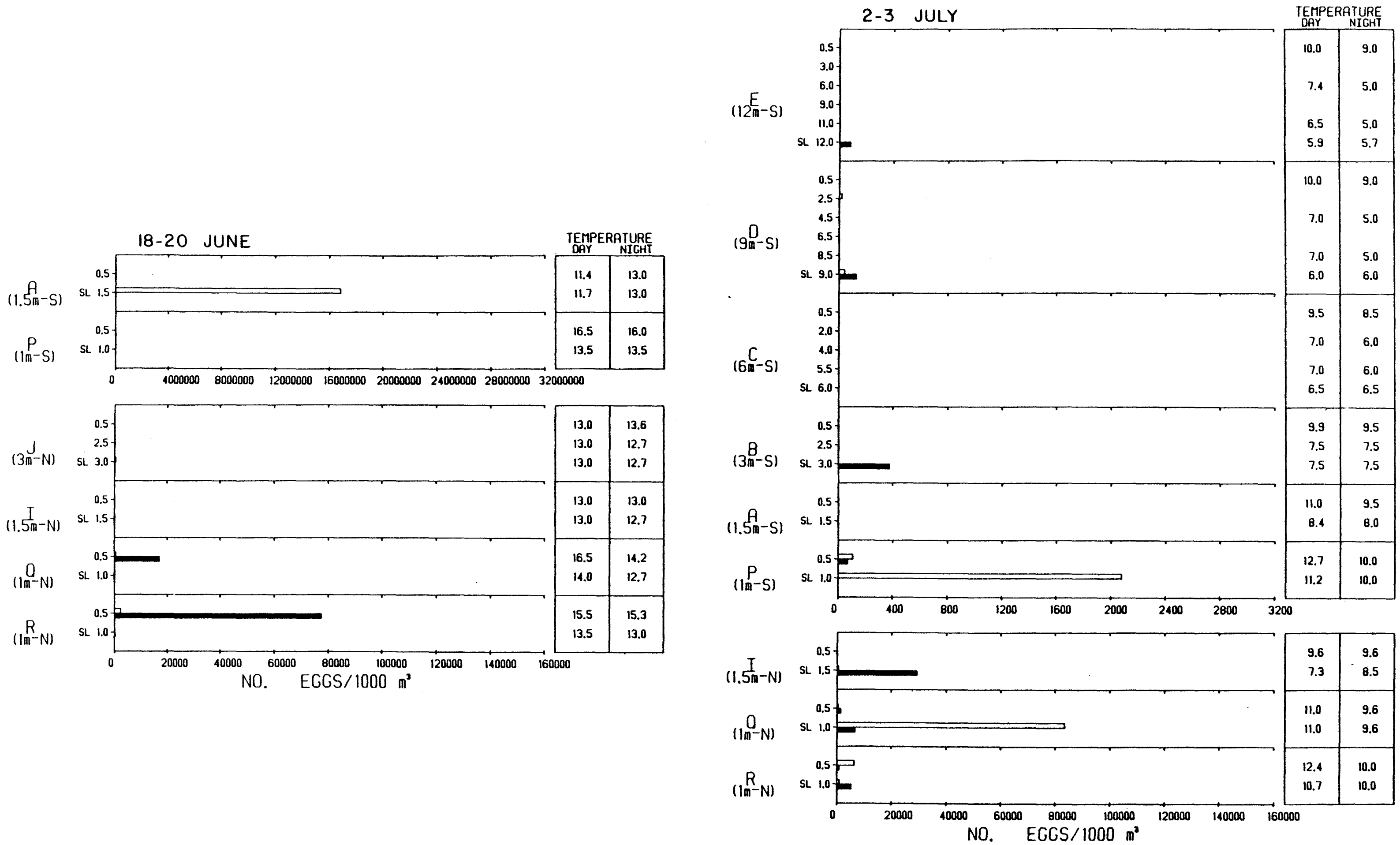


Fig. 125. Density of fish eggs (no./1000 m^3) at Lake Michigan stations near the J.H. Campbell Plant eastern Lake Michigan June to September 1979. □ = day, ■ = night, SL = sled.



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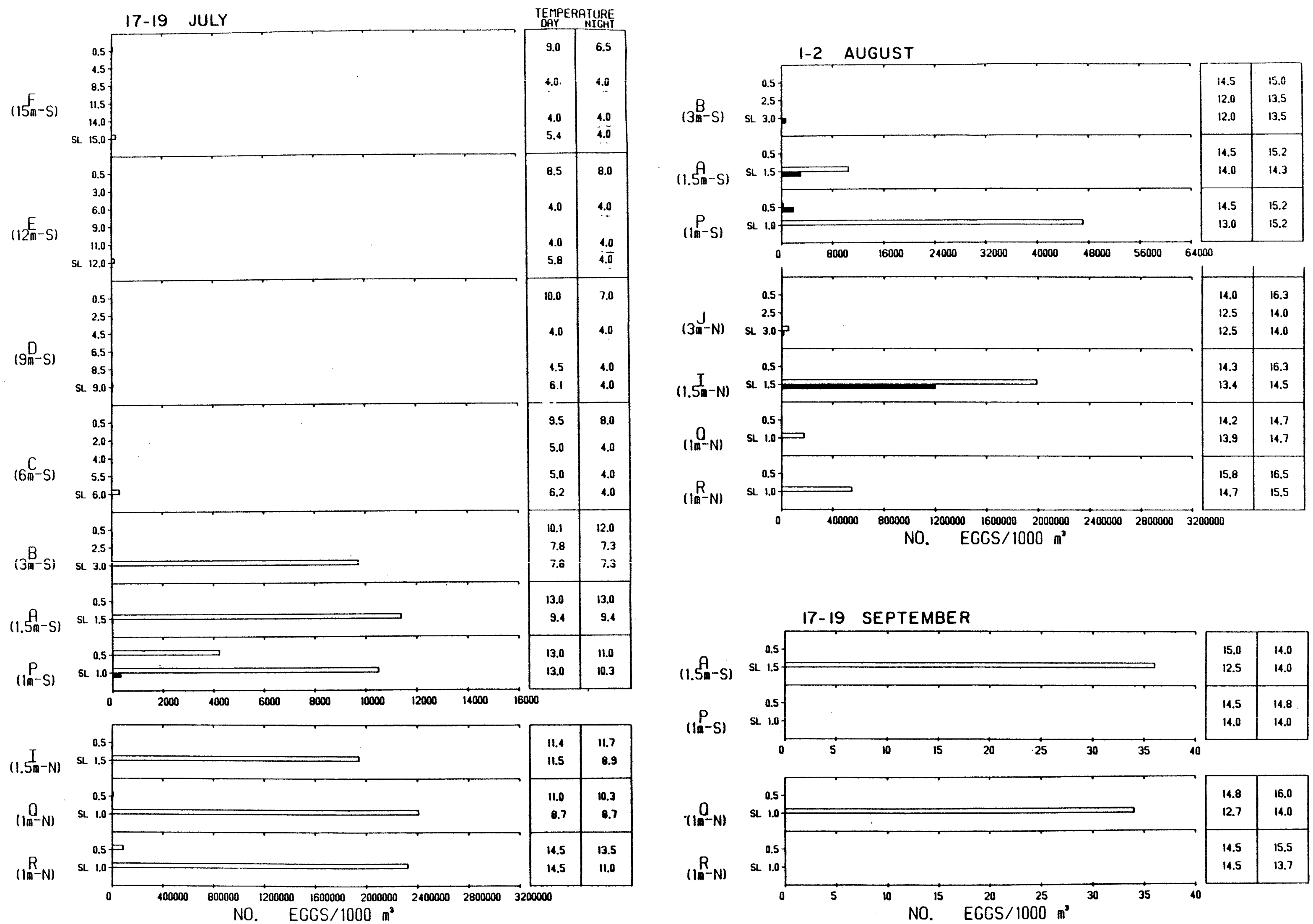

Fig. 125. Continued.

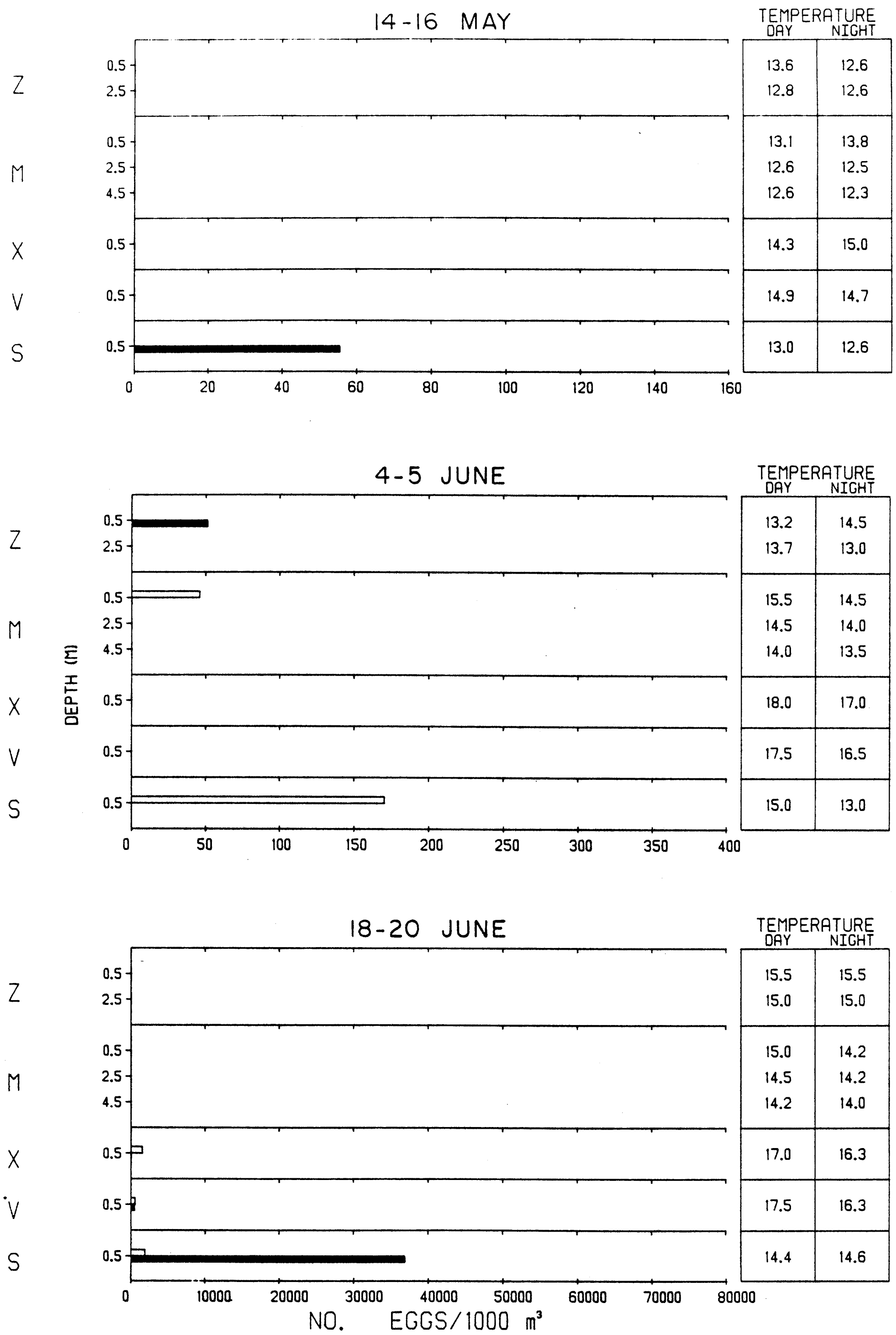

Fig. 126. Density of fish eggs (no./1000 m^3) at Pigeon Lake and intake canal stations near the J.H. Campbell Plant, eastern Lake Michigan May to August 1979. Stations Z(intake canal), M(6 m, openwater), X(1 m, openwater), V(beach, undisturbed) and S(beach, Lake Michigan influenced) are shown. □ = day, ■ = night.

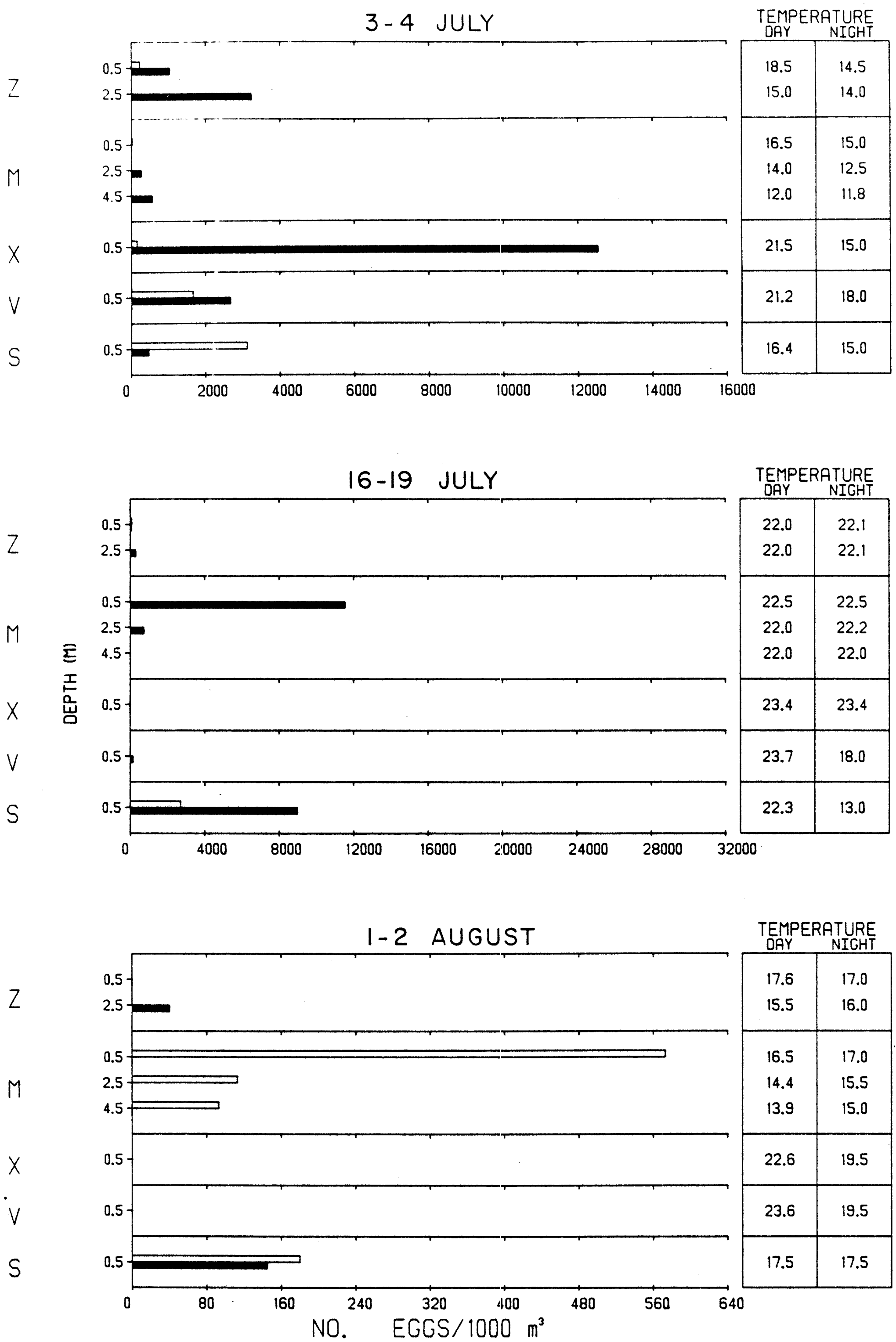

Fig. 126. Continued.

Pigeon Lake the intensity of spawning at Lake Michigan influenced stations apparently had increased compared with early July. Spawning at stations in Pigeon Lake not influenced by Lake Michigan continued at low levels.

Distributional trends of fish eggs at Lake Michigan stations in early August were very similar to late July. Densities of eggs at north transect stations showed decreases in early August; whereas, the trend was reversed at south transect stations. In general, it is probable that the intense spawning activity which occurred in the discharge canal and surrounding area had reached its peak in late July, and had begun to taper off in early August. This declining trend was also indicated by lower egg densities at Pigeon Lake stations in early August (Fig. 126).

From late August to September fish eggs were found on only two occasions (Appendixes 10-12) in field samples, indicating that spawning for the 1979 season ceased by late August. With the exception of one high density of eggs observed on 20-21 August, entrainment fish egg densities paralleled field collections.

Entrainment--

Eggs observed in entrainment samples in late January and early February were most probably those of burbot. Estimated total number of eggs entrained for both January and February exceeded 13.7 million eggs. Using average fecundity data presented by Muth (1973) for burbot in Lake of the Woods, Minnesota, this estimate of burbot eggs entrained approximates the fecundity of 38 fish. It is difficult to relate this amount of entrainment to an appreciable effect on the Lake Michigan burbot population; however, initial indications suggest that the effects are minimal. In addition, the eggs may not be affected by plant passage. Burbot use of the area near the Campbell Plant for spawning apparently exhibits extreme yearly variation. Burbot larvae experienced a substantially decreased entrainment loss during 1979 compared with 1978 (see YEARLY ENTRAINMENT SUMMARY).

The next major entrainment of fish eggs occurred in May. Throughout this month densities of eggs were high (Fig. 124) resulting in an estimated entrainment of over 24.9 million fish eggs. These eggs were mostly those of carp which exhibited intense spawning activity in the intake canal during May. In relating the entrainment loss of carp eggs to an effect on the Pigeon Lake ecosystem, two factors should be considered. First, intense spawning activity occurred in the intake canal. Since the canal is not a natural part of Pigeon Lake and, as we believe, the majority of carp eggs entrained are not drawn from Pigeon Lake but rather are spawned in the canal itself, the effect of carp egg entrainment on Pigeon Lake stocks is probably minimal. A second factor to consider is fecundity of this species. Swee and McCrimmon (1966) reported carp fecundity varied from 36,000 eggs in age-4 (394 mm) fish to 2.2 million eggs in an age-16 (851 mm) fish. Using these two figures as extremes, the entrainment loss of carp eggs at the Campbell Plant in May approximates the total fecundity of 12-711 carp. Again, eggs may survive plant passage and end up being deposited in Lake Michigan.

Densities of eggs in entrainment samples were highest during June and July. Eggs entrained during these months were probably those of alewives, spottail shiner, carp and emerald shiner. The exact proportion, however, could not be determined. An estimated 286 million eggs were entrained in June and 2,900 million were entrained during July at the Campbell Plant. These estimates are in stark contrast with 1978 when an estimated 89.9 million eggs were entrained in June and only 75 million were entrained during July.

Reasons for the substantial increases in egg entrainment during 1979 are not known. It may be that cooler water temperatures in Lake Michigan induced more alewives (compared with previous years) to spawn in Pigeon Lake. Thus, more alewife eggs could have been entrained. During warmer years, more Lake Michigan spawning takes place, and eggs have sufficient time to hatch before being drawn into the plant. This may also explain the lower occurrence of larval alewives in Pigeon Lake during 1979. Since no gill nets could be set in Pigeon Lake during June or July, the contention that spawning alewives were present more than in previous years remains highly speculative.

August marked the final month in which eggs were entrained. With the exception of 21 August night samples, densities of eggs in entrained water were quite low. Eggs entrained in August probably represented late spawning spottail shiners and alewives. Again, the estimated total entrained for the month (nearly 6 million), exceeded the August 1978 estimate (over 2 million). The reason for this may be that the spawning peak for alewives during 1979 was in August, a month later than during 1978. Thus, more alewife eggs were present in August 1979, resulting in higher entrainment.

YEARLY ENTRAINMENT SUMMARY

Yearly entrainment estimates for 1978 (Jude et al. 1979a) were calculated in a slightly different manner in this report (see METHODS - ENTRAINMENT). Thus values from the 1978 study will sometimes not agree with those given in this report. Further refinements in our computer programs and more accurate partitions of time intervals were responsible for this change.

During 1979 the estimated entrainment of larvae at the J. H. Campbell Plant was approximately 69.9 million which is less than the estimated 77.7 million larvae entrained during 1978 (Table 43). A summary of monthly entrainment totals during 1977-1979, along with upper and lower error bounds is presented in Tables 44-46. As during 1978, the greatest entrainment rate during 1979 belonged to alewives. This species exhibited maximum entrainment during July and August of both years, as would be expected from our observations of field larvae and the adult alewife reproductive cycle. Estimated numbers of alewife larvae entrained in 1979 (over 23 million) were less than half that reported in 1978 (over 48 million). This accounted in part for the numerical dominance of alewives decreasing from over 60% of the larvae entrained for 1978 to less than 34% of the total number of larvae entrained in 1979.

Table 43. Projected numbers of various taxons of larval fish and fish eggs entrained during 1977, 1978 and 1979 at the J. H. Campbell Plant, eastern Lake Michigan. Estimates were derived from densities of larvae and eggs observed in 16 samples collected during a 24-h period, usually once per week. The 1977 data are for July to December only. Column numbers may not sum to totals because of rounding.

Taxon	1977	1978	1979
Alewife	63,700,000	48,900,000	23,400,000
Spottail shiner	256,000	25,800	8,460,000
Trout-perch	7,450	4,690	86,500
Yellow perch	7,450	16,200,000	14,600,000
Rainbow smelt	39,500	1,530,000	1,610,000
Carp	176,000	1,510,000	11,200,000
Pomoxis spp.	268,000	960,000	6,090,000
Unidentified fish		4,900	6,290
Unidentified *Lepomis*	5,050	58,700	86,000
Unidentified *Cyprinidae*	10,900,000	2,930,000	335,000
Unidentified *Etheostoma*	7,490		3,790
Gizzard shad		92,200	37,700
Largemouth bass		1,430	
Ninespine stickleback		16,500	
White sucker		10,200	
Bluegill		47,300	
Burbot		1,560,000	810
Pumpkinseed		27,000	
Emerald shiner		9,830	321,000
Unidentified coregoninae		22,900	607
Fourhorn sculpin		227,000	166,000
Goldfish		35,800	
Johnny darter		9,530	27,400
Unidentified Catostomidae		60,800	19,100
Damaged larvae	101,000	3,510,000	3,410,000
Slimy sculpin			3,790
Brook silverside			2,630
Bluntnose minnow			6,500
Total No. Larvae Entrained	75,500,000	77,700,000	69,900,000
Total No. Fish Eggs Entrained	14,400,000	163,000,000	3,250,000,000

Table 44. Projected numbers of various taxons of fish larvae and of fish eggs entrained during July through December 1977 at the J. H. Campbell Plant, eastern Lake Michigan. Estimates were derived from densities of larvae observed in 16 samples collected during a 24-h period, usually once per week during July through December 1977. Also included are estimated upper and lower bounds of error for the projected numbers of larvae and eggs entrained.

TAXON	MONTH Jul	Aug	Sep	Oct	Nov	Dec	SUM	% OF TOTAL
Alewife	41,200,000	21,300,000	947,000	150,000	97,800	0	63,700,000	84.398
Upper Bound	51,000,000	23,800,000	1,170,000	229,000	181,000	0	76,000,000	
Lower Bound	31,500,000	18,800,000	722,000	70,600	14,600	0	51,400,000	
Unidentified Cyprinidae	10,900,000	52,900	0	5,660	0	0	10,900,000	14.453
Upper Bound	12,400,000	101,000	0	22,700	0	0	12,400,000	
Lower Bound	9,310,000	5,280	0	0	0	0	9,370,000	
Pomoxis spp.	268,000	0	0	0	0	0	268,000	0.355
Upper Bound	387,000	0	0	0	0	0	437,000	
Lower Bound	148,000	0	0	0	0	0	98,800	
Spottail Shiner	122,000	134,000	0	0	0	0	256,000	0.339
Upper Bound	246,000	223,000	0	0	0	0	451,000	
Lower Bound	0	45,300	0	0	0	0	61,300	
Carp	176,000	0	0	0	0	0	176,000	0.233
Upper Bound	313,000	0	0	0	0	0	351,000	
Lower Bound	38,300	0	0	0	0	0	0	
Damaged Larvae	101,000	0	0	0	0	0	101,000	0.134
Upper Bound	181,000	0	0	0	0	0	205,000	
Lower Bound	21,600	0	0	0	0	0	0	
Rainbow Smelt	8,370	22,600	4,680	3,870	0	0	39,500	0.052
Upper Bound	27,200	48,700	15,200	11,600	0	0	77,000	
Lower Bound	0	0	0	0	0	0	2,030	
Etheostoma spp.	7,490	0	0	0	0	0	7,490	0.010
Upper Bound	22,500	0	0	0	0	0	22,500	
Lower Bound	0	0	0	0	0	0	0	
Yellow Perch	7,450	0	0	0	0	0	7,450	0.010
Upper Bound	24,800	0	0	0	0	0	24,800	
Lower Bound	0	0	0	0	0	0	0	
Trout-perch	7,450	0	0	0	0	0	7,450	0.010
Upper Bound	24,800	0	0	0	0	0	24,800	
Lower Bound	0	0	0	0	0	0	0	
Lepomis spp.	0	5,050	0	0	0	0	5,050	0.007
Upper Bound	0	16,400	0	0	0	0	16,400	
Lower Bound	0	0	0	0	0	0	0	
Total No. of Larvae Entrained	52,800,000	21,500,000	952,000	160,000	97,800	0	75,500,000	
Upper Bound	63,100,000	24,000,000	1,170,000	240,000	181,000	0	86,100,000	
Lower Bound	42,400,000	19,000,000	728,000	79,200	14,600	0	64,800,000	
Total No. of Eggs Entrained	14,400,000	0	0	0	0	0	14,400,000	
Upper Bound	18,200,000	0	0	0	0	0	19,300,000	
Lower Bound	10,600,000	0	0	0	0	0	9,470,000	

Table 45. Projected numbers of various taxons of fish larvae and of fish eggs entrained during 1978 at the J. H. Campbell Plant, eastern Lake Michigan. Estimates were derived from densities of larvae observed in 16 samples collected during a 24-h period, usually once per week during 1978. Also included are estimated upper and lower bounds of error for the projected numbers of larvae and eggs entrained.

TAXON	MONTH												SUM	%OF TOTAL
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Alewife	0	0	0	13,200	160,000	3,440,000	17,700,000	13,700,000	280,000	12,400,000	1,180,000	0	48,900,000	62.903
Upper Bound	0	0	0	32,100	318,000	4,440,000	20,300,000	16,500,000	375,000	24,600,000	1,470,000	0	64,400,000	
Lower Bound	0	0	0	0	2,630	2,440,000	15,200,000	10,900,000	185,000	162,000	890,000	0	33,300,000	
Yellow Perch	0	0	0	71,900	15,800,000	266,000	28,600	0	0	0	0	0	16,200,000	20.811
Upper Bound	0	0	0	103,000	17,600,000	375,000	73,600	0	0	0	0	0	18,400,000	
Lower Bound	0	0	0	40,700	14,000,000	157,000	0	0	0	0	0	0	13,900,000	
Damaged Larvae	0	0	0	42,300	1,200,000	732,000	724,000	645,000	4,620	151,000	6,120	0	3,510,000	4.518
Upper Bound	0	0	0	65,000	1,540,000	1,040,000	1,340,000	1,370,000	12,100	358,000	19,400	0	5,440,000	
Lower Bound	0	0	0	19,500	869,000	425,000	105,000	0	0	0	0	0	1,580,000	
Unidentified Cyprinidae	0	0	0	6,180	20,700	990,000	1,520,000	384,000	9,440	0	0	0	2,930,000	3.770
Upper Bound	0	0	0	14,200	43,500	1,320,000	1,740,000	510,000	35,400	0	0	0	3,490,000	
Lower Bound	0	0	0	0	0	664,000	1,300,000	258,000	0	0	0	0	2,370,000	
Burbot	0	0	0	1,110,000	419,000	27,000	0	0	0	0	0	0	1,560,000	2.007
Upper Bound	0	0	0	1,540,000	648,000	81,000	0	0	0	0	0	0	2,400,000	
Lower Bound	0	0	0	684,000	190,000	0	0	0	0	0	0	0	714,000	
Rainbow Smelt	0	0	0	0	785,000	701,000	34,200	7,630	0	0	0	0	1,530,000	1.968
Upper Bound	0	0	0	0	1,030,000	871,000	76,000	26,700	0	0	0	0	1,940,000	
Lower Bound	0	0	0	0	538,000	531,000	0	0	0	0	0	0	1,120,000	
Carp	0	0	0	0	66,000	819,000	604,000	20,900	0	0	0	0	1,510,000	1.944
Upper Bound	0	0	0	0	105,000	1,000,000	649,000	47,200	0	0	0	0	1,790,000	
Lower Bound	0	0	0	0	26,700	639,000	560,000	0	0	0	0	0	1,230,000	
Pomoxis spp.	0	0	0	0	206,000	725,000	3,230	26,400	0	0	0	0	960,000	1.236
Upper Bound	0	0	0	0	273,000	909,000	10,500	56,600	0	0	0	0	1,240,000	
Lower Bound	0	0	0	0	138,000	540,000	0	0	0	0	0	0	684,000	
Fourhorn Sculpin	4,760	9,520	0	213,000	0	0	0	0	0	0	0	0	227,000	0.293
Upper Bound	16,100	32,100	0	382,000	0	0	0	0	0	0	0	0	448,000	
Lower Bound	0	0	0	44,200	0	0	0	0	0	0	0	0	6,760	
Gizzard Shad	0	0	0	0	39,900	34,600	9,970	7,670	0	0	0	0	92,200	0.119
Upper Bound	0	0	0	0	110,000	88,600	27,000	28,800	0	0	0	0	215,000	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	
Unidentified Catostomidae	0	0	0	16,200	44,600	0	0	0	0	0	0	0	60,800	0.078
Upper Bound	0	0	0	25,100	69,100	0	0	0	0	0	0	0	94,300	
Lower Bound	0	0	0	7,280	20,000	0	0	0	0	0	0	0	27,300	
Lepomis spp.	0	0	0	1,650	4,540	3,260	40,500	8,710	0	0	0	0	58,700	0.076
Upper Bound	0	0	0	6,610	18,200	10,200	93,800	26,300	0	0	0	0	118,000	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	
Bluegill	0	0	0	0	0	47,300	0	0	0	0	0	0	47,300	0.061
Upper Bound	0	0	0	0	0	98,900	0	0	0	0	0	0	98,900	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	

Table 45. Continued.

TAXON	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	SUM	%CF TOTAL
	MONTH													
Goldfish	0	0	0	0	4,900	0	30,900	0	0	0	0	0	35,800	0.046
Upper Bound	0	0	0	0	14,700	0	99,000	0	0	0	0	0	105,000	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	
Pumpkinseed	0	0	0	0	0	27,000	0	0	0	0	0	0	27,000	0.035
Upper Bound	0	0	0	0	0	81,000	0	0	0	0	0	0	81,000	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	
Spottail Shiner	0	0	0	0	0	12,700	6,630	6,420	0	0	0	0	25,800	0.033
Upper Bound	0	0	0	0	0	42,900	16,100	19,500	0	0	0	0	71,800	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	
Unidentified Coregoninae	0	0	0	18,500	4,440	0	0	0	0	0	0	0	22,900	0.029
Upper Bound	0	0	0	52,400	15,200	0	0	0	0	0	0	0	59,700	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	
Ninespine Stickleback	0	0	0	0	5,460	11,100	0	0	0	0	0	0	16,500	0.021
Upper Bound	0	0	0	0	17,600	36,000	0	0	0	0	0	0	51,200	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	
White Sucker	0	0	0	2,720	7,480	0	0	0	0	0	0	0	10,200	0.013
Upper Bound	0	0	0	5,560	15,300	0	0	0	0	0	0	0	20,800	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	
Emerald Shiner	0	0	0	0	0	0	9,830	0	0	0	0	0	9,830	0.013
Upper Bound	0	0	0	0	0	0	34,400	0	0	0	0	0	34,400	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	
Johnny Darter	0	0	0	0	0	9,530	0	0	0	0	0	0	9,530	0.012
Upper Bound	0	0	0	0	0	33,400	0	0	0	0	0	0	33,400	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	
Unidentified Pisces	0	0	0	544	1,500	0	2,860	0	0	0	0	0	4,900	0.006
Upper Bound	0	0	0	1,630	4,490	0	9,040	0	0	0	0	0	13,900	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	
Trout-perch	0	0	0	0	1,840	0	2,860	0	0	0	0	0	4,690	0.006
Upper Bound	0	0	0	0	6,120	0	8,570	0	0	0	0	0	13,600	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	
Largemouth Bass	0	0	0	0	0	1,430	0	0	0	0	0	0	1,430	0.002
Upper Bound	0	0	0	0	0	4,760	0	0	0	0	0	0	4,760	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total No. Larvae Entrained	4,760	9,520	0	1,500,000	18,800,000	7,850,000	20,700,000	14,800,000	294,000	12,500,000	1,190,000	0	77,700,000	
Upper Bound	16,100	32,100	0	1,990,000	20,800,000	9,070,000	23,300,000	17,700,000	397,000	24,700,000	1,480,000	0	90,800,000	
Lower Bound	0	0	0	1,010,000	16,800,000	6,630,000	18,200,000	11,900,000	191,000	309,000	894,000	0	64,600,000	
Total No. Eggs Entrained	0	0	0	228,000	1,120,000	90,100,000	70,400,000	1,340,000	0	0	5,240	29,500	163,000,000	
Upper Bound	0	0	0	601,000	2,200,000	119,000,000	90,900,000	2,880,000	0	0	15,900	89,600	214,000,000	
Lower Bound	0	0	0	0	40,300	60,700,000	49,900,000	0	0	0	0	0	112,000,000	

Table 46. Projected numbers of various taxons of fish larvae and of fish eggs entrained during 1979 at the J. H. Campbell Plant, eastern Lake Michigan. Estimates were derived from densities of larvae observed in 16 samples collected during a 24-h period, usually once per week during 1979. Also included are estimated upper and lower bounds of error for the projected numbers of larvae and eggs entrained.

TAXON	MONTH Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	SUM	%OF TOTAL
Alewife	0	0	0	0	2,550	157,000	12,300,000	8,430,000	2,060,000	252,000	171,000	0	23,400,000	33.482
Upper Bound	0	0	0	0	7,650	254,000	16,000,000	9,310,000	2,780,000	334,000	279,000	0	28,600,000	
Lower Bound	0	0	0	0	0	59,700	8,610,000	7,550,000	1,350,000	169,000	62,700	0	18,200,000	
Yellow Perch	0	0	0	251,000	13,900,000	142,000	307,000	6,910	0	0	0	0	14,600,000	20.851
Upper Bound	0	0	0	318,000	18,100,000	186,000	448,000	17,400	0	0	0	0	20,000,000	
Lower Bound	0	0	0	183,000	9,650,000	97,200	166,000	0	0	0	0	0	9,100,000	
Carp	0	0	0	0	3,150,000	307,000	7,680,000	109,000	0	0	0	0	11,200,000	16.085
Upper Bound	0	0	0	0	3,500,000	381,000	8,920,000	151,000	0	0	0	0	12,500,000	
Lower Bound	0	0	0	0	2,800,000	233,000	6,430,000	67,500	0	0	0	0	9,950,000	
Spottail Shiner	0	0	0	162	29,200	549,000	4,680,000	3,190,000	0	10,800	0	0	8,460,000	12.104
Upper Bound	0	0	0	486	67,000	651,000	5,560,000	3,600,000	0	40,500	0	0	10,000,000	
Lower Bound	0	0	0	0	0	447,000	3,800,000	2,770,000	0	0	0	0	6,920,000	
Pomoxis spp.	0	0	0	0	5,860,000	92,800	121,000	15,300	0	0	0	0	6,090,000	8.714
Upper Bound	0	0	0	0	7,280,000	135,000	166,000	36,500	0	0	0	0	7,520,000	
Lower Bound	0	0	0	0	4,440,000	51,000	76,200	0	0	0	0	0	4,660,000	
Damaged Larvae	0	0	0	12,500	2,450,000	290,000	503,000	135,000	22,800	0	0	0	3,410,000	4.882
Upper Bound	0	0	0	26,700	3,310,000	422,000	793,000	206,000	72,200	0	0	0	4,330,000	
Lower Bound	0	0	0	0	1,590,000	157,000	213,000	63,700	0	0	0	0	2,490,000	
Rainbow Smelt	0	0	0	0	1,240,000	314,000	47,800	6,820	3,820	0	0	0	1,610,000	2.304
Upper Bound	0	0	0	0	1,470,000	412,000	74,400	21,100	13,400	0	0	0	1,950,000	
Lower Bound	0	0	0	0	1,010,000	216,000	21,100	0	0	0	0	0	1,270,000	
Unidentified Cyprinidae	0	0	0	0	850	49,300	106,000	178,000	0	0	0	0	335,000	0.479
Upper Bound	0	0	0	0	3,400	82,400	198,000	384,000	0	0	0	0	582,000	
Lower Bound	0	0	0	0	0	16,200	13,900	0	0	0	0	0	86,900	
Emerald Shiner	0	0	0	0	0	4,350	79,000	230,000	7,600	0	0	0	321,000	0.459
Upper Bound	0	0	0	0	0	12,800	166,000	338,000	22,800	0	0	0	595,000	
Lower Bound	0	0	0	0	0	0	0	121,000	0	0	0	0	47,300	
Fourhorn Sculpin	0	43,700	72,600	48,900	566	0	0	0	0	0	0	0	166,000	0.237
Upper Bound	0	87,100	139,000	115,000	2,270	0	0	0	0	0	0	0	320,000	
Lower Bound	0	327	6,570	0	0	0	0	0	0	0	0	0	11,300	
Trout-perch	0	0	0	19,900	9,360	17,700	0	16,800	22,800	0	0	0	86,500	0.124
Upper Bound	0	0	0	54,600	22,300	38,300	0	40,500	70,700	0	0	0	155,000	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	17,900	
Lepomis spp.	0	0	0	0	0	0	11,600	74,500	0	0	0	0	86,000	0.123
Upper Bound	0	0	0	0	0	0	28,200	109,000	0	0	0	0	158,000	
Lower Bound	0	0	0	0	0	0	0	40,300	0	0	0	0	14,200	
Gizzard Shad	0	0	0	0	15,200	4,540	0	0	17,900	0	0	0	37,700	0.054
Upper Bound	0	0	0	0	32,400	16,200	0	0	46,400	0	0	0	72,900	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	2,390	

Table 46. Continued.

TAXON	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	SUM	%CF TOTAL
	MONTH													
Johnny Darter	0	0	0	0	0	0	2,180	16,100	9,130	0	0	0	27,400	0.039
Upper Bound	0	0	0	0	0	0	7,620	31,700	31,900	0	0	0	63,400	
Lower Bound	0	0	0	0	0	0	0	411	0	0	0	0	0	
Unidentified														
Catostomidae	0	0	0	1,660	17,500	0	0	0	0	0	0	0	19,100	0.027
Upper Bound	0	0	0	3,100	31,400	0	0	0	0	0	0	0	34,400	
Lower Bound	0	0	0	214	3,520	0	0	0	0	0	0	0	3,820	
Bluntnose Minnow	0	0	0	0	0	3,850	2,650	0	0	0	0	0	6,500	0.009
Upper Bound	0	0	0	0	0	9,410	8,840	0	0	0	0	0	14,800	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	
Unidentified														
Pisces	0	0	0	0	850	0	5,440	0	0	0	0	0	6,290	0.009
Upper Bound	0	0	0	0	3,400	0	16,900	0	0	0	0	0	18,000	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	
Slimy Sculpin	0	0	0	0	0	3,790	0	0	0	0	0	0	3,790	0.005
Upper Bound	0	0	0	0	0	13,300	0	0	0	0	0	0	13,300	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	
Etheostoma spp.	0	0	0	0	0	3,790	0	0	0	0	0	0	3,790	0.005
Upper Bound	0	0	0	0	0	13,300	0	0	0	0	0	0	13,300	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	
Brook Silverside	0	0	0	0	0	0	2,630	0	0	0	0	0	2,630	0.004
Upper Bound	0	0	0	0	0	0	8,160	0	0	0	0	0	8,160	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	
Burbot	0	0	0	81	729	0	0	0	0	0	0	0	810	0.001
Upper Bound	0	0	0	324	2,920	0	0	0	0	0	0	0	3,240	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	
Unidentified														
Coregoninae	0	0	0	607	0	0	0	0	0	0	0	0	607	0.001
Upper Bound	0	0	0	2,430	0	0	0	0	0	0	0	0	2,430	
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total No. Larvae														
Entrained	0	43,700	72,600	334,000	26,600,000	1,940,000	25,900,000	12,400,000	2,150,000	262,000	171,000	0	69,900,000	
Upper Bound	0	87,100	139,000	431,000	32,100,000	2,220,000	31,100,000	13,500,000	2,870,000	352,000	279,000	0	77,600,000	
Lower Bound	0	327	6,570	238,000	21,200,000	1,660,000	20,700,000	11,300,000	1,430,000	173,000	62,700	0	62,200,000	
Total No. Eggs														
Entrained	6,390,000	7,320,000	0	128,000	24,900,000	286,000,000	2,920,000,000	5,990,000	0	0	0	0	3,250,000,000	
Upper Bound	10,600,000	11,200,000	0	371,000	43,700,000	371,000,000	4,630,000,000	12,600,000	0	0	0	0	4,960,000,000	
Lower Bound	2,180,000	3,460,000	0	0	6,130,000	201,000,000	1,210,000,000	0	0	0	0	0	1,540,000,000	

Substantial increased egg entrainment occurred during July and August 1979 compared with 1978 (a high percentage of which were probably alewives). Entrained eggs of any species include those eggs which are dead and those unfertilized. Data on natural viability and hatchability of eggs prior to entrainment are lacking. Thus an assessment of the effect on respective fish populations of entraining large numbers of their eggs is difficult to make. Of the live eggs which pass through the Campbell Plant there is some indication that they may survive the increased temperature (10 C) imposed by plant passage itself (Schubel 1975). However, this author also noted that plants with long discharge canals, which extend the duration of higher temperatures, may impose increased mortality on eggs depending on their retention time in the entrained water.

Yellow perch accounted for 21% of the larvae entrained during both 1978 and 1979, which was higher than that reported during 1978 (0.01%). Numerically, this species was subject to less entrainment in 1979 (estimated over 14.6 million) than in 1978 (estimated over 16.2 million). Early appearance (April-May) of yellow perch larvae in 1979 suggests that Pigeon Lake was the origin of perch larvae entrained during these months. Continual occurrence of many small yellow perch larvae during June-August indicates larvae entrained during these months were probably being drawn from Lake Michigan. The rationale for this contention is discussed in FISH EGGS AND LARVAE, Yellow Perch. It is difficult to determine the effect of yellow perch entrainment on local populations. The majority of larval yellow perch entrained were observed in May (over 13,9 million larvae) and thus Pigeon Lake is suspected as their origin. If this is the case, the extraordinarily high catches of YOY yellow perch in August at Pigeon Lake stations in 1979 suggest that the effect of larval yellow perch entrainment was minimal.

A significant increase in the number of carp larvae entrained occurred in 1979 (over 11.2 million carp larvae entrained) compared with 1978 (less than 1.6 million carp larvae entrained). Many carp larvae entrained may have been spawned in the intake canal itself. This is particularly evident in May when densities of carp larvae at station Z (near the mouth of the intake canal) seemed significantly lower than entrainment values, indicating recruitment of larvae from the intake canal between these two collection points.

Entrainment loss of spottail shiners increased in 1979 compared with 1978. Assuming that most larvae designated as unidentified Cyprinidae entrained in 1978 were spottail shiners, less than 3 million were entrained from May to September 1978. During 1979 an estimated 8.46 million spottail larvae were entrained. Part of the increased entrainment loss of spottail larvae was probably due to increased reproductive activity in the intake canal as was noted for carp. The extent of intake canal production, however, is unknown. It is likely that increased entrainment estimates for carp are largely reflective of the yearly variation of spawning activity near the plant.

Larvae of unidentified Pomoxis spp. were also subject to increased entrainment at the Campbell Plant since in excess of 6 million were entrained during 1979 (compared with less than 1 million entrained in 1978). Smelt larvae accounted for 2.3% of the larvae entrained during 1979 (over 1.6 million smelt larvae entrained) showing only a slight numerical increase over numbers entrained in 1978. Maximum smelt entrainment occurred in May, as expected from knowledge of their life history near the Campbell Plant. Maximum entrainment of smelt fry occurred from August to October. Substantial increased entrainment of emerald shiner larvae, as well as bluntnose minnow larvae probably reflects our increased ability to identify these larvae. Inclusion of these larvae in the unidentified Cyprinidae classification during 1978, precludes an accurate comparison with 1979 data.

Entrainment of fourhorn sculpins showed some decrease during 1979 (166,000 entrained) compared with 1978 (227,000 entrained); again, this increase probably reflects natural yearly variability. Other species which showed increased entrainment during 1979 included Lepomis spp., trout-perch and johnny darters. Decreased entrainment during 1979 was noted for unidentified coregoninae, gizzard shad and unidentified Catostomidae. Although ninespine sticklebacks, bluegills, pumpkinseeds, largemouth bass and goldfish were entrained during 1978, none were observed in entrainment samples in 1979. Species absent from 1978 samples reported entrained in 1979 included slimy sculpins, brook silversides, bluntnose minnow and unidentified Etheostoma spp.

In general, it would be expected that entrainment estimates for most species found near the Campbell Plant would exhibit considerable yearly variation. The intake design of Units 1 and 2 is unique and involves water withdrawal from a number of distinct aquatic habitats. There are a number of factors precluding any simplistic approach to predicting entrainment at the Campbell Plant. Primary to a consideration of which Lake Michigan species might be entrained would be the percent composition of cooling water (how much from Pigeon River, Pigeon Lake and Lake Michigan) used by the plant and how they coincided with peak spawning times in Lake Michigan. If a period of less rainfall (and hence less river flow) coincided with peak spawning/hatching activity in Lake Michigan, Lake Michigan water would comprise a higher percentage of the cooling water during this crucial period. Thus higher entrainment losses of Lake Michigan larvae would be expected to occur. Under heavy rainfall conditions, the converse might be expected, resulting in higher entrainment losses of Pigeon Lake/Pigeon River-spawned larvae.

Climatological factors, which have been shown in past years to influence larval fish distribution near the Campbell Plant could also be expected to impart variability to our entrainment estimates. During years when smaller pelagic larvae are present coincident with forces that dispersed larvae into areas influenced by intake currents, parallel increased entrainment losses could be expected. Climatological factors which influence larval fish distribution are perhaps the most difficult to document. Thus, entrainment losses at the Campbell Plant in any 1 yr involve the interaction of a number of complex factors ranging from biological aspects (times of peak spawning activity) to geological (river flows) and climatological factors.

SCUBA OBSERVATIONS

Monthly Observations

April--

In April, no fish were observed. Visibility was 0.3 m.

May--

One johnny darter (≈50 mm), one goldfish (350 mm) and one carp (760 mm) were observed. Visibility was 1 m.

June--

No fish were observed. Visibility was 1 m.

July--

One spottail shiner and one yellow perch (≈125 mm) were observed. Visibility was 2 m.

August--

The largest number of fish observed during the year included 125 johnny darters (20-165 mm), 31 yellow perch (125-225 mm), 1 large carp (≈700 mm) along with many schools of YOY alewives and spottail shiners. Visibility was 3 m.

September--

Fish observed included 37 johnny darters (25-50 mm), 40 spottail shiners (20-40 mm), *Coregonus* spp.; YOY alewife were very abundant. All observations were made along the eastern bank in less than 1 m of water. Visibility was 1 m.

October--

All fish were observed along the eastern bank in less than 1 m of water including 30 johnny darters (15-75 mm) and one YOY alewife. Visibility was 0.3 m.

November--

About 25-30 johnny darters (30-40 mm) were observed. Visibility was 0.5 m.

Summary

Extremely poor visibility prevented an estimation of seasonal occurrence and abundance of fish in the intake canal. Nearly all fish observed were viewed in very shallow water along the east side of the canal. A population of johnny darters seems to inhabit the intake canal. Large schools of YOY alewives and spottail shiners indicate that the intake canal is a nursery area for these species.

GENERAL SUMMARY AND CONCLUSIONS

INTRODUCTION

Major effort in this study was directed at securing larval, juvenile and adult fish data which are statistically sound, gathered during critical life history periods and pertinent to answering questions regarding any possible effects of the Campbell Plant on Lake Michigan fish populations. We collected adult fish in Lake Michigan using trawls, seines and surface and bottom gill nets. These gear were fished at plant-affected and reference transects. Larval fish were sampled using horizontally towed plankton nets and a sled. Impingement of fish was regularly monitored throughout the year and entrainment rates of fish larvae were determined from diel and seasonal samples collected. SCUBA observations were carried out in the intake canal to determine what species were utilizing this area for food, cover and spawning. Results of these 1979 activities comprised the bulk of this report along with complementary information from our 1977 and 1978 studies and literature reviews. In the following sections, we will provide a summary of pertinent findings from the various subject areas covered which include: statistics, all major fish (under which all pertinent field data for adults and larvae plus entrainment and impingement will be discussed), minor species, impingement and entrainment.

STATISTICS

Any study generating data must consider design, replication and variability in order to predict or ascertain changes in the populations of interest. Our major concern in preoperational years has been establishing the suitability of our reference transect as a control for our plant-affected transect. Since the thermal effluent in operational years will be discharged near 6 m in Lake Michigan adult fish catches at that station have been compared statistically with catches from the reference transect. Data were transformed and ANOVA techniques employed for catch data for six major species (spottail shiner, yellow perch, alewife, trout-perch, unidentified coregoninae, rainbow smelt) collected with trawls. For spottail shiners, significant differences in catches among preoperational years (1977-1979) and between stations (C-reference, L-plant) were noted. Station differences were also noted for rainbow smelt, unidentified coregoninae and yellow perch. No differences were observed for alewife over years or between stations. Data were sufficient for ANOVA for only three species collected in bottom gill nets. Two designs were used, one with 1977 data and one without. In the first design, no significant catch differences were shown between reference and plant stations for alewife, spottail shiner or yellow perch; differences among years were found for spottails and alewives. In the second design (1978-1979 data), there were no year effects, but differences in catch of spottails and alewives were observed between south (reference) and north transect stations at both 6 and 9 m. These differences will make operational comparisons more difficult, although it will be possible to determine if changes in preoperational years exceed those observed in operational years. For surface gill nets, only alewives were abundant enough for the analysis and only Time of Day (more caught during nighttime) was significant. The seine

ANOVA design was utilized for spottail shiners and alewives. Significant Year and Month effects were noted for both species, while only spottails showed a statistically significant increase at plant-affected beach station R (north discharge) when compared with reference beach station P.

Month effects were significant for almost all ANOVA designs, and were probably related to spawning activity, inshore migration, and recruitment of YOY. Upwellings and weather-effected changes in distribution were also important during certain years.

Least Detectable True Ratios (LDTRs) were calculated to give an estimation of the power of our designs to detect changes as reflected by our index catches (geometric mean catch). We found that most of our sampling designs could probably detect increases in mean abundance from one station (or area) to another in the range 15% to 50% and decreases from 13% to 33%. LDTRs were highest for surface gill nets. Among species, power to detect changes was lowest for alewife. The trawl was the best gear to use.

ALEWIFE

Alewives have remained the dominant species numerically in our catches in the Campbell Plant vicinity. Field catches have declined consistently from 1977 levels of 53,864 to 1978 levels of 44,617 to 1979 catches of 28,490 fish. This decline has been noted lake wide and may be partially responsible for the upswing in unidentified coregoninae populations also observed. Alewife spawning has occurred in Pigeon Lake as evidenced by entrainment of larvae and impingement of large numbers of adults in May through July. Intensity of spawning appeared to be dampened considerably, because of upwellings which were persistent and had very low water temperatures in July. YOY were abundant in August, but almost half as numerous as in 1978. More spawning occurred in the vicinity of Lake Michigan beach stations Q and R (discharge) which were influenced by the onshore warm-water plume. More fish larvae and adults were collected there. In 1979 an estimated 71,372 fish were impinged, with 25,070 of that amount occurring in November. Many of these are believed to have originated from the discharge canal. In 1978, over 48 million larvae were entrained, while in 1979 less than half, 23.4 million, were entrained. However, spectacular increases in egg entrainment from 163 million in 1978 to over 3 billion in 1979 were observed. Fry entrainment also increased in 1979 when compared with 1978 levels. Salmonids and many predators in Pigeon Lake feed heavily on alewives during seasons when their distributions overlap. Alewife populations were not greatly affected by plant operations.

RAINBOW SMELT

Many YOY and yearling smelt, but few adult smelt, were caught during 1979. An apparent alternate year-class cycle was observed from examination of 1977-1979 catch data. YOY populations were high in 1977 and 1979 and low in 1978; whereas, yearling levels were low in 1977 and 1979 and high in 1978. Most smelt YOY were caught at the 9- to 12-m depth contours in August and September. Similar growth occurred in 1978-1979. YOY were 40 mm in August, 50 mm in October and 60 mm in December. Few smelt were ever caught in Pigeon

Lake ruling it out as a significant spawning or nursery area. Some larval smelt were collected in May at beach station V (undisturbed Pigeon Lake), but they may have come from Lake Michigan. Adults preferred colder water than YOY and came inshore during upwellings. Adults spawned later than expected (late June) again in 1979.

Mostly YOY (1333) were impinged in 1978; more (2513) were impinged in 1979. Similar numbers of smelt larvae (1.5 million and 1.6 million) were entrained respectively in 1978 and 1979. Most occurred in May and June. An additional 2 million fry (greater than 25.4 mm) were entrained during 1979, most in August (1.3 million).

SPOTTAIL SHINER

Field catches of spottails were most consistent among the last 3 yr in both Lake Michigan (1977-7883 fish, 1978-12,764 fish, 1979-9749 fish) and Pigeon Lake (1977-4457 fish, 1978-2456 fish, 1979-3194 fish). Most caught in 1979 ranged from 85 to 135 mm. The lower number of fish observed in 1979 was due to lower YOY catches, due possibly to the cold year with many upwellings, which may have lowered the number of spottails produced. Most spottails were caught in summer at stations with the warmest water available. Most were caught at 6- and 9-m stations. More were caught at plant-influenced stations than at reference stations. More larval spottails were collected at north transect stations also, indicating spawning in or near the onshore discharge canal. There was a substantial increase in entrainment of spottails as 1978 levels for unidentified cyprinids (believed to be mostly spottails) were less than 3 million, while in 1979 8 million spottail larvae were entrained. This increase is believed to have occurred because of favorable spawning conditions in the intake canal in 1979. The plant was shut down during part of May and the water in the canal, which is believed to have warmed, was current free and apparently considerable spawning by spottails and other species (e.g., carp) occurred. When the plant went back on-line, many of their larvae were entrained. SCUBA observations verified that many schools of small spottails and alewives (less than 24 mm) were present in the intake canal. We believe the loss of spottails to be minimal because of the contribution of the intake canal. Population levels have also remained stable over the 3 yr.

YELLOW PERCH

In 1979, 8700 perch were collected in the vicinity of the Campbell Plant. This was over twice as many as were caught during 1977 (3713) and 1978 (2849). Most of this 1979 total (8195) was derived from enormous seine catches at Pigeon Lake stations. Previous seine catches in Pigeon Lake were considerably smaller, being 2308 in 1977 and 1616 in 1978. Most of the 1979 Pigeon Lake seine catches were YOY, showing that a strong year class had developed. Age data showed yellow perch at any given age were similar in size whether derived from Pigeon Lake or Lake Michigan. Interestingly, extremely high densities of yellow perch larvae were also observed at Pigeon Lake beach station V; very few were collected there during 1978. Larval fish length-frequency data showed that in early spring (April-May) large numbers of perch larvae were produced in Pigeon Lake, resulting in over 14.6 million larvae

being entrained for 1979. In 1978 over 16 million were entrained. Later in June, more perch larvae from Lake Michigan were also entrained. At this time, length-frequency data clearly showed the modes of both the Pigeon Lake-produced larvae and those spawned in Lake Michigan. Also in 1979, 1439 perch were estimated as having been impinged. This number was comparable to 1978 levels of 1519. A few perch are eaten by northern pike and our surveys have shown that large numbers are removed from the lake and river every year by sport fishermen. A survey of sport fishermen on Pigeon Lake conducted during 1980 (Jude et al. 1980) showed at least 8000 yellow perch were removed from the lake.

UNIDENTIFIED COREGONINAE

There has been a statistically significant increase in the number of what we believe to be mostly bloaters (unidentified coregoninae) in our catches of 1977 to 1979. In 1977 they comprised 0.6% (460) of our total catch, in 1978 it was 3% (3121) and in 1979 they had risen to comprise 7% (5713) of our total catch. Most were caught in trawls. We were able to identify three groups from our sampling. YOY (60-100 mm) are present from September to December, yearlings (100-160 mm) from June to September and age-2+ fish (>160 mm) are present from June to September. Those over 200 mm are mostly mature. Most fish were collected in water 6 m or deeper at temperatures between 6 and 11 C. Many were collected during upwellings. None have been found in predator stomachs. More fish were caught at the north rather than the reference transect. They were rarely impinged (69 in 1978, 68 in 1979) but some larvae (22,900 in 1978, 607 in 1979) were entrained. Seven larvae 10-15 mm were caught during 1978, while in 1979 13 were collected in field samples.

TROUT-PERCH

Field catches of trout-perch were similar in 1978 (1861) and 1979 (1755). Catch from 1977 to 1978 increased substantially while no change was observed between 1978 and 1979. Most were trawled; one was collected in a surface gill net. There is apparently no trout-perch spawning occurring in Pigeon Lake. Some yearlings, however, were seined at beach station S. Most trout-perch were caught at 6-12 m at night. There was an apparent nocturnal inshore movement. No strong temperature preference was shown by these fish. A strong 1977 year class was produced which has dominated the catch each year through early 1979. Later in 1979, few of these now age-3+ fish were collected. In 1978, 1283 trout-perch were impinged, followed by 2063 in 1979. Most were impinged in November-March when an open gate allowed intake forebay access by fish inhabiting the discharge canal. Few trout-perch larvae have been captured. Four were caught in 1977 and 1978. In 1979, 27 larvae and 11 fry were collected, all at north transect (plant influenced) stations in sled tow samples from 6-m depths or greater. In 1978, 4690 trout-perch were entrained, while in 1979 over 86 thousand were entrained.

MINOR SPECIES

Johnny darters experienced a 48% increase in Pigeon Lake catches from 1978 to 1979. In Lake Michigan during 1979, 405 were caught, mostly at night. Most were caught at 6- to 9-m stations in summer. They moved to deeper water late in winter. None were impinged. In 1979 27,374 were estimated entrained which was more than in 1978 (8170). Few (16 larvae) were collected in 1979 field samples. YOY were observed by SCUBA divers to be abundant in the intake canal in 1979.

White suckers are common around the plant all year. In Lake Michigan, 413 were collected in 1979, while 22 were caught in Pigeon Lake. Similar numbers were observed in 1977-1978. A few were caught in surface gill nets in Lake Michigan. No significant spawning has been apparent in the Pigeon Lake-Pigeon River system. White suckers spawn in rivers in April and leave presumably for deeper water in the winter. Impingement losses totalled 215 fish in 1979; none were entrained. In 1978, over 60 thousand suckers (either white or longnose) were entrained.

Bluntnose minnows exhibited a decline in 1979 over 1978 levels. None was impinged, while 6,500 were entrained. Ninespine sticklebacks spawned at Pigeon Lake beach station S in 1978; this was not observed in 1979. A few fish (90) were impinged in 1979 mostly during March to July. They spawned in April in Pigeon Lake and June-July in Lake Michigan. No lake trout were caught in Pigeon Lake during 1979, while 222 were taken in Lake Michigan. Twenty-five were impinged in 1979. Lake trout eggs were observed in stomachs of round whitefish collected during November. Peak catch of lake trout was during the spawning season, October-November. Many were also caught during upwellings. Lamprey scarring declined from 36% in 1978 to 24% in 1979. Fresh scars also declined from 15% to less than 1%. Trout ate gizzard shad, spottail shiners, trout-perch, cyprinids, centrarchids, but mainly alewives and smelt.

Longnose sucker catches in 1979 were 208 for Lake Michigan and 13 for Pigeon Lake. A few YOY were seined. Longnose suckers spawned in April; some were caught at night at 1.5 and 3 m in July, but most were taken at 6 and 9 m. They were abundant during July upwellings. Three were impinged in 1979. Slimy sculpins moved inshore in April and May to spawn. They moved offshore when water temperatures exceeded 10 C. We sample only the fringes of this deep water population. Emerald shiner was a major species in Pigeon Lake in 1978 due to high catches at beach station S. We did not collect many there in 1979. Adults were caught in April-May in both lakes; young fish reappeared again in the fall. Their population decline may be related to alewives. YOY emerald shiner catches were inversely correlated with alewife abundance. In 1979 321,000 emerald shiners were entrained.

Brown trout catches declined from 115 in 1978 to 88 in 1979. Many juveniles were caught in the beach zone in June 1978; few were collected in 1979 despite similar stocking rates both years. All came from water 6 m or less, except two fish. They ate slimy sculpins in spring and alewives the remainder of the year. In 1979, 32 were impinged; all were juveniles. Most

chinook salmon collected were 100-400 mm in length. In 1978, 33 were collected, while in 1979 catches were 79 fish. Impingement rates were identical in 1978-1979 (143 fish). Many were collected in April in gill nets in water 1.5-12 m. In 1979, 75% of the fish collected were from 77 to 187 mm. One 335-mm fish was collected in Pigeon Lake. Mottled sculpins were only collected in Pigeon Lake. More were caught in 1979 than in 1978. Thirty-six were impinged. June was the first occurrence of largemouth bass in Pigeon Lake. YOY 15-19 mm were seined from station V. September samples contained the largest catches. Most were immature fish 45-96 mm. Impingement losses were 1202 fish, mostly YOY. None were entrained.

More round whitefish were caught in 1979 (44) than 1978 (10). Most were caught in October-November. None were entrained or impinged. Black crappie catches in Pigeon Lake declined from 246 to 49 fish in 1978-1979. In 1979, 432 were impinged. Large numbers (over 6 million) of crappies were entrained in 1979; only 960,000 were entrained during 1978. Large numbers entrained during 1979 were attributed to plant shutdown and subsequent quiet water during May 1979 which afforded crappies ideal spawning conditions. A major population of gizzard shad exists in the discharge canal. In Lake Michigan 37 were captured in 1979; they ranged from 395 to 467 mm. In 1977 (7 mo), 165,219 were impinged, followed by 74,727 and 40,573 respectively for 1978 and 1979. Most shad impinged in 1979 were 140-180 mm. Most larvae were entrained during May-June in 1979; 37,700 passed through the plant. In 1978, we had difficulty identifying shad larvae which are very closely related to alewife larvae.

Only 37 rock bass were collected in 1979 which is a decline from 1978 levels (76). No larval rock bass were sampled. In 1978, 21 were impinged while 28 were lost during 1979. Twenty-nine rainbow trout were collected during 1979; most were large fish 540-740 mm. Ten and 15 were caught respectively in 1977 and 1978. They were in the discharge canal during late winter and fall feeding on alewives and gizzard shad. Six were impinged in 1979; all in December. Lake whitefish were collected in all 3 yr of the study: 1977 (11), 1978 (9), 1979 (26). Specimens in 1979 were 155-597 mm. None were impinged or collected in Pigeon Lake. Pumpkinseeds were collected only in Pigeon Lake; 23 were caught. In 1978, 114 were collected. Forty-six were impinged in 1979. Coho salmon were collected in Pigeon Lake (3) and Lake Michigan (18) during 1979. No juveniles were seined in the Lake Michigan beach zone as was found in previous years. In 1979, 26 coho were impinged.

Golden shiners experienced a precipitous decline from 2220 in 1978 to 20 in 1979 Pigeon Lake samples. Most of the decline in catch was due to lack of capture of YOY, which apparently were outcompeted by an abundant yellow perch year class in 1979. Impingement rate was 199 fish in 1979. Tadpole madtoms were collected in small numbers (17) during 1978-1979 in Pigeon Lake. Forty-two were impinged in 1979. None were entrained. There has been no large change in carp catches between 1978 (21) and 1979 (10). All were adults 580-740 mm. Five immatures were impinged. Large numbers of carp (11.2 million) were entrained during 1979. As was seen for other species, plant shutdown in May proved advantageous for spawning carp in the intake canal. Ten golden redhorses and two sea lampreys were observed in field and

impingement samples during 1979. Brown bullhead catches remained low (9 were caught) in 1979. Twenty-nine were impinged. Nine banded killifish (30-50 mm) were seined in Pigeon Lake at station V. Northern pike were common in 1978 Pigeon Lake samples, but deletion of gill nets from the 1979 sample design caused zero catches in 1979. However, 285 fish were impinged; all were YOY or yearlings.

Seven channel catfish were collected in 1979, all in Lake Michigan. They were 55-590 mm. Total impingement loss was 53 fish; 21 were impinged in January. Low numbers of brook silversides were caught in Pigeon Lake during 1979. Only eight were impinged. Three immature logperch, never before collected in field samples, were caught in Pigeon Lake seines. Three bowfins were caught and 14 impinged during 1979. One lake sturgeon, a threatened species, was caught and released from a gill net at 6-m station L. It was 795 mm long and estimated to be 15-yr old. No burbot were collected in 1979; however, 126 were impinged during cold months when spawning was suspected of occurring in both lakes. Some burbot were also caught in a winter gill net set in Pigeon Lake. Entrainment data supported hypothesized spawning as 1.6 million larvae passed through the plant in 1978 in April-June while in 1979, 810 were entrained in April.

Walleyes, an important sport fish, were not collected in field samples. In 1978, 115 were impinged, while in 1979, 75 were impinged. They were present in the discharge canal during cold months. There is a thriving population of quillbacks in the discharge canal. In 1979, 37 were impinged despite none ever being caught in either lake. In July quillback YOY were seen in the canal. Five flathead catfish were impinged in 1979. This is a rare species in the vicinity. Blackside darters are common in the Pigeon River and stray into the lake. We collected two fish in 1979. Their presence was verified with SCUBA observations.

IMPINGEMENT

In 1979, total impingement loss at Campbell was 127,760 fish. Gizzard shad (40,573), alewife (71,372), spottail shiner (6111), smelt (2513), trout-perch (2063), yellow perch (1439) and largemouth bass (1202) were the major species impinged. Most fish (31,275) were impinged in November, followed by January (24,171), October (13,835) and July (10,884). Major impingement of trout-perch, alewife, bass and shad occurred in the late fall-winter when a gate necessary for warm-water recirculation allowed fish from the discharge canal access to the intake forebay. Forty-three species of fish were impinged during 1979.

The 127,760 fish impinged by the plant in 1979 contrasts with an estimated 252,674 fish which were reported impinged from 13 June to 22 December 1977 (Zeitoun et al. 1978) and 136,737 fish impinged in 1978. The 1978 total impingement loss was again comprised mainly of alewife (45,722), gizzard shad (74,727), spottail shiner (5673) and largemouth bass (3061). December (33,045), March (20,929), January (19,963) and June (15,609) were

months of major impingement. Many of the fish impinged during winter months originated from the discharge canal and passed into the intake forebay via an open gate.

ENTRAINMENT

At least 22 different species or groups of larvae were entrained during 1979. Total loss was 69.90 million larval fish. Of this total, alewives (23.40 million), yellow perch (14.60 million), carp (11.2 million), spottail shiners (8.46 million), crappies (6.09 million), larvae in poor condition (3.41 million) and rainbow smelt (1.61 million) comprised over 98% of all larvae entrained. Major entrainment occurred in May (26.6 million), July (25.9 million) and August (12.4 million). Other species such as burbot and fourhorn sculpin were entrained early in the year. Alewives were entrained over the greatest time span from May through September.

In 1978 more larvae were entrained, since 77.7 million was the projected loss for the year. Alewife (48.9 million) and yellow perch (16.2 million) were the two major species entrained followed by damaged larvae (3.51 million), unidentified Cyprinidae (2.93 million), burbot (1.56 million), rainbow smelt (1.53 million) and carp (1.51 million). An additional 16 species groups comprised the remaining larvae entrained. Four months, May-August, were times of maximum entrainment with the following respective numbers of larvae entrained: 18.8 million; 7.85 million; 20.7 million; 14.8 million.

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APPENDIXES
TO

ADULT, JUVENILE AND LARVAL FISH POPULATIONS IN THE VICINITY OF THE J. H. CAMPBELL POWER PLANT, EASTERN LAKE MICHIGAN, 1979

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December, 1980

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Alphabetical listing of code letters and common names of all species of fish captured in the vicinity of the J.H. Campbell Plant from January through December 1979.

Code	Common name	Code	Common Name
AL	Alewife	MA	Silver Redhorse
BB	Black Bullhead	MS	Mottled Sculpin
BC	Black Crappie	MT	Tadpole Madtom
BD	Blackside Darter	NP	Northern Pike
BF	Bowfin	NS	Ninespine Stickleback
BG	Bluegill	PM	Unidentified *Pomoxis* spp.
BK	Banded Killifish	PP	Fathead Minnow
BM	Bluntnose Minnow	PS	Pumpkinseed
BN	Brown Bullhead	QL	Quillback
BR	Burbot	RB	Rock Bass
BT	Brown Trout	RT	Rainbow Trout
CC	Channel Catfish	RW	Round Whitefish
CH	Chinook Salmon	SB	Smallmouth Bass
CM	Coho Salmon	SH	Sand Shiner
CP	Carp	SL	Sea Lamprey
CS	Common Shiner	SM	Rainbow Smelt
ES	Emerald Shiner	SP	Spottail Shiner
FC	Flathead Catfish	SR	Shorthead Redhorse
FS	Fourhorn Sculpin	SS	Slimy Sculpin
GF	Goldfish	SV	Brook Silverside
GL	Golden Shiner	TP	Trout-perch
GN	Green Sunfish	WL	Walleye
GP	Grass Pickerel	WS	White Sucker
GR	Golden Redhorse	XC	Unidentified Coregoninae
GS	Gizzard Shad	XE	Unidentified *Etheostoma* spp.
JD	Johnny Darter	XL	Unidentified *Lepomis* spp.
LB	Largemouth Bass	XM	Unidentified Cyprinidae
LG	Lake Sturgeon	XP	Damaged Larvae
LP	Logperch	XS	Unidentified Catostomidae
LS	Longnose Sucker	XX	Unidentified Pisces
LT	Lake Trout	YB	Yellow Bullhead
LW	Lake Whitefish	YP	Yellow Perch

Appendix 1. Physical and limnological parameters measured at the time gill nets were set.

STARTING DATE	TIME START	TIME FINISH	STATION	TEMPERATURE C SURFACE	TEMPERATURE C FISH DEPTH	WIND DIR. FROM	WIND SPEED MPH	WAVES DIR. FROM	WAVES HT. (M)	WEATHER	SECCHI DISC (M)
4-17-79	1110	1920	A	6.0	6.5	NE	5-10	NW	0.6-1.0	CLEAR	1.0
4-16-79	2035	0700	A	7.3	7.3	NW	10-15	NW	0.3-0.6	CLEAR	___
4-17-79	0931	1925	B	6.0	6.0	NW	5-10	NW	0-0.3	CLEAR	1.5
4-16-79	2045	0707	B	8.0	8.0	NW	10-15	NW	0.3-0.6	CLEAR	___
4-17-79	0940	1907	C	5.0	5.3	NW	5-10	NW	0-0.3	CLEAR	2.0
4-16-79	1952	0643	C	6.5	6.5	NW	10-15	NW	0-0.3	CLEAR	___
4-16-79	0945	1900	C*	5.0	5.0	NW	5-10	NW	0-0.3	CLEAR	2.0
4-16-79	1943	0630	C*	6.5	6.5	VAR	5-10	NW	0-0.3	CLEAR	___
4-17-79	0955	1847	D	3.4	3.4	NW	5-10	NW	0-0.3	CLEAR	3.0
4-16-79	2003	0653	D	6.5	6.0	NW	5-10	NW	0-0.3	CLEAR	___
4-17-79	1005	1836	E	2.0	2.5	NW	5-10	NW	0-0.3	CLEAR	3.5
4-16-79	2013	0705	E	3.0	3.0	NW	5-10	NW	0-0.3	CLEAR	___
4-17-79	1020	1850	L	3.0	3.5	NW	10-15	NW	0-0.3	CLEAR	2.5
4-16-79	2005	0630	L	3.9	3.9	S	10-15	SE	0.3-0.6	PT CLOUDY	___
4-17-79	1010	1835	L*	3.0	3.0	NW	10-15	NW	0-0.3	CLEAR	2.5
4-16-79	1945	0620	L*	3.9	3.9	SE	10-15	SE	0.3-0.6	CLEAR	___
4-18-79	0950	1845	M	8.2	7.0	NW	0-5	NW	0-0.3	CLEAR	1.5
4-17-79	1100	1845	U*	3.0	3.0	NW	5-10	NW	0-0.3	CLEAR	2.5
4-16-79	2015	0645	U*	3.9	3.9	S	10-15	SE	0.3-0.6	PT CLOUDY	___
5-15-79	0800	1830	A	11.8	11.8	NW	0-5	NW	0-0.3	CLEAR	BOTTOM
5-15-79	1830	0545	A	14.0	12.7	NW	0-5	NW	0-0.3	CLEAR	___
5-15-79	0745	1845	B	13.0	13.5	NW	0-5	NW	0-0.3	CLEAR	1.8-2.0
5-15-79	1845	0553	B	14.0	12.3	NW	0-5	NW	0-0.3	CLEAR	___
5-15-79	0720	1915	C	12.3	12.5	NW	0-5	SW	0-0.3	CLEAR	2.0
5-15-79	1900	0605	C	13.4	10.6	NW	0-5	SW	0-0.3	CLEAR	2.0
5-15-79	0710	1900	C*	12.3	12.3	NW	0-5	SW	0-0.3	CLEAR	---
5-15-79	1900	0600	C*	13.4	13.4	NW	0-5	SW	0-0.3	CLEAR	___
5-15-79	0725	1905	D	12.0	11.6	NW	5-10	NW	0-0.3	CLEAR	2.0
5-15-79	2105	0620	D	12.5	9.5	NW	0-5	NW	0-0.3	CLEAR	___
5-15-79	0745	1915	E	11.0	11.5	NW	5-10	NW	0-0.3	CLEAR	2.5
5-15-79	2050	0626	E	12.5	10.0	NW	0-5	NW	0-0.3	CLEAR	___
5-15-79	0710	1827	L	13.0	11.5	NW	5-10	SW	0-0.3	CLEAR	2.0
5-15-79	2125	0555	L	14.0	12.0	NW	0-5	NW	0-0.3	CLEAR	___
5-15-79	0645	1845	L*	13.0	13.0	NW	5-10	SW	0-0.3	CLEAR	1.5
5-15-79	1845	0545	L*	14.0	14.0	CALM	0-5	CALM	0-0.3	CLEAR	___
5-15-79	0700	1835	U*	13.0	13.0	NW	5-10	SW	0-0.3	CLEAR	1.5
5-15-79	1835	0550	U*	14.0	14.0	NW	5-10	NW	0-0.3	CLEAR	___
6-19-79	1040	1933	A	11.4	11.7	SE	15-20	SE	0-0.3	CLEAR	BOTTOM
6-18-79	2105	0505	A	13.9	12.3	E	0-5	CALM	0-0.3	CLEAR	___
6-19-79	1035	1925	B	11.6	11.2	SE	15-20	SE	0-0.3	CLEAR	3.0
6-18-79	2110	0515	B	12.0	11.7	E	0-5	CALM	0-0.3	CLEAR	___
6-19-79	1030	1910	C	11.8	11.3	SE	15-20	SE	0-0.3	CLEAR	3.3
6-18-79	2115	0535	C	12.4	11.7	E	0-5	CALM	0-0.3	CLEAR	___
6-19-79	1025	1900	C*	11.8	11.8	SE	15-20	SE	0-0.3	CLEAR	3.3
6-18-79	2125	0525	C*	12.4	12.4	E	0-5	CALM	0-0.3	CLEAR	___
6-19-79	1015	1853	D	11.7	9.0	SE	15-20	SE	0-0.3	CLEAR	4.0
6-18-79	2130	0538	D	12.4	10.3	E	0-5	CALM	0-0.3	CLEAR	___
6-19-79	1000	1843	E	12.0	7.5	SE	15-20	SE	0-0.3	CLEAR	3.8
6-18-79	2135	0554	E	11.5	9.7	E	0-5	CALM	0-0.3	CLEAR	___
6-19-79	0800	1840	L	12.0	9.5	E	5-10	E	0-0.3	CLEAR	2.0
6-18-79	2030	0518	L	12.5	11.2	E	5-10	E	0-0.3	PT CLOUDY	___
6-19-79	0755	1850	L*	12.0	12.0	SE	10-15	SE	0-0.3	CLEAR	2.0
6-18-79	2025	0505	L*	12.5	12.5	E	10-15	E	0-0.3	PT CLOUDY	___
6-19-79	0805	1900	U*	12.0	12.0	SE	10-15	E	0-0.3	CLEAR	2.0
6-18-79	2035	0525	U*	12.4	12.4	E	10-15	E	0-0.3	CLEAR	___

Appendix 1. Continued.

STARTING DATE	TIME START	TIME FINISH	STATION	TEMPERATURE C SURFACE	TEMPERATURE C FISH DEPTH	WIND DIR. FROM	WIND SPEED MPH	WAVES DIR. FROM	WAVES HT. (M)	WEATHER	SECCHI DISC (M)
7-16-79	0645	1500	A	21.5	21.3	NW	0-5	NW	0-0.3	CLEAR	BOTTOM
7-17-79	2025	0520	A	10.5	10.5	N	0-5	NW	0.3-0.6	CLEAR	---
7-17-79	0620	1708	B	12.0	9.0	NE	5-10	NW	0.3-0.6	PT CLOUDY	2.0
7-17-79	2030	0555	B	9.5	9.5	N	0-5	NW	0.3-0.6	CLEAR	---
7-16-79	0655	1505	C	21.0	20.6	NW	0-5	NW	0-0.3	CLEAR	3.5
7-17-79	2040	0545	C	8.5	6.5	N	0-5	NW	0.3-0.6	CLEAR	---
7-16-79	0700	1500	C*	21.0	21.0	NW	0-5	NW	0-0.3	CLEAR	3.5
7-17-79	2040	0540	C*	8.5	8.5	NW	0-5	NW	0-0.3	CLEAR	---
7-16-79	0710	1510	D	21.0	20.5	NW	0-5	NW	0-0.3	CLEAR	4.0
7-17-79	2100	0534	D	8.5	5.5	NE	5-10	NW	0.3-0.6	CLEAR	---
7-16-79	0720	1517	E	20.5	15.0	N	0-5	NW	0.3-0.6	CLEAR	4.5
7-17-79	2110	0516	E	8.5	5.5	NE	5-10	NW	0.3-0.6	CLEAR	---
7-16-79	0805	1421	L	21.5	19.2	N	0-5	NW	0.6-1.0	CLEAR	3.5
7-17-79	2100	0545	L	10.0	7.3	NW	0-5	NW	0.3-0.6	CLEAR	---
7-16-79	0755	1413	L*	21.5	21.5	N	0-5	NW	0.6-1.0	CLEAR	3.5
7-17-79	2050	0530	L*	10.0	10.0	NW	0-5	NW	0.3-0.6	CLEAR	---
7-16-79	0745	1425	U*	21.5	21.5	N	0-5	NW	0.6-1.0	CLEAR	3.5
7-17-79	2043	0537	U*	10.0	10.0	NW	0-5	NW	0.3-0.6	CLEAR	---
8-21-79	0940	2045	A	15.3	15.5	E	0-5	SE	0-0.3	CLEAR	BOTTOM
8-20-79	2130	0615	A	14.5	13.8	CALM	0-5	CALM	0-0.3	CLEAR	---
8-21-79	0945	2040	B	15.3	15.3	E	0-5	SE	0-0.3	CLEAR	BOTTOM
8-20-79	2045	0625	B	15.0	14.5	CALM	0-5	CALM	0-0.3	CLEAR	---
8-21-79	1000	2035	C	15.0	14.8	E	0-5	SE	0-0.3	CLEAR	4.5
8-20-79	2030	0630	C	15.0	14.5	CALM	0-5	CALM	0-0.3	CLEAR	---
8-21-79	0950	2030	C*	15.0	15.0	E	0-5	CALM	0-0.3	CLEAR	4.5
8-20-79	2035	0632	C*	15.0	15.0	CALM	0-5	CALM	0-0.3	CLEAR	---
8-21-79	1005	2015	D	15.0	14.5	E	0-5	CALM	0-0.3	CLEAR	4.5
8-20-79	2025	0645	D	15.0	14.5	CALM	0-5	CALM	0-0.3	CLEAR	---
8-21-79	1015	2008	E	15.2	14.5	E	0-5	CALM	0-0.3	CLEAR	4.0
8-20-79	2015	0655	E	15.0	14.7	CALM	0-5	CALM	0-0.3	CLEAR	---
8-21-79	0845	1925	L	16.0	14.0	E	0-5	CALM	0-0.3	CLEAR	4.0
8-20-79	2045	0630	L	14.8	13.6	CALM	0-5	CALM	0-0.3	PT CLOUDY	---
8-21-79	0845	1935	L*	16.0	16.0	E	0-5	CALM	0-0.3	CLEAR	4.0
8-20-79	2035	0620	L*	14.8	14.8	CALM	0-5	CALM	0-0.3	PT CLOUDY	---
8-21-79	0845	1918	U*	16.0	16.0	E	0-5	CALM	0-0.3	CLEAR	4.0
8-20-79	2100	0638	U*	15.7	15.7	CALM	0-5	CALM	0-0.3	PT CLOUDY	---
9-19-79	0815	1730	A	14.3	13.3	NE	15-20	NW	0.3-0.6	CLEAR	1.5
9-19-79	1730	0655	A	15.0	15.0	NW	0-5	NW	0-0.3	CLEAR	---
9-19-79	0750	1743	B	15.0	14.0	NE	5-10	NW	0.3-0.6	CLEAR	1.4
9-19-79	1743	0645	B	15.0	15.0	SW	5-10	SW	0.6-1.0	CLEAR	---
9-19-79	0807	1804	C	14.5	12.5	NE	5-10	NW	0.3-0.6	CLEAR	2.25
9-19-79	1804	0650	C	14.5	14.2	SW	5-10	SW	0.6-1.0	CLEAR	---
9-19-79	0812	1757	C*	14.2	14.8	NE	5-10	NW	0.3-0.6	CLEAR	2.25
9-19-79	1757	0715	C*	14.5	14.5	SW	5-10	SW	0.6-1.0	CLEAR	---
9-19-79	0817	1817	D	15.2	12.3	NE	5-10	NW	0.3-0.6	CLEAR	2.5
9-19-79	1817	0700	D	14.5	14.5	SW	5-10	SW	0.6-1.0	CLEAR	---
9-19-79	0825	1720	E	14.8	11.7	NE	5-10	NW	0.3-0.6	CLEAR	2.0
9-19-79	1800	0640	E	14.5	11.5	VAR	5-10	VAR	0-0.3	CLEAR	---
9-19-79	0740	1800	L	12.5	11.7	NE	15-20	NW	0.6-1.0	CLEAR	2.5
9-19-79	1800	0650	L	14.0	13.0	VAR	10-15	NW	0.3-0.6	CLEAR	---
9-19-79	0750	1715	L*	12.5	12.5	NE	15-20	NW	0.6-1.0	CLEAR	2.5
9-19-79	1715	0750	L*	14.0	14.0	VAR	10-15	NW	0.3-0.6	CLEAR	---
9-19-79	0800	1810	U*	12.5	12.5	NE	15-20	NW	0-0.3	CLEAR	2.5
9-19-79	1810	0640	U*	14.0	14.0	VAR	10-15	NW	0.3-0.6	CLEAR	---
10-16-79	0855	1711	A	13.2	13.0	E	0-5	SW	0.3-0.6	RAIN	BOTTOM
10-16-79	1945	0745	A	12.4	12.4	WSW	5-10	SW	0.3-0.6	FOG	---
10-16-79	0730	1655	B	13.2	13.5	SE	0-5	SW	0.3-0.6	RAIN	3.0
10-16-79	1930	0739	B	13.6	13.5	SW	5-10	SW	0.6-1.0	OVERCAST	---
10-16-79	0740	1710	C	13.5	13.6	SE	0-5	SW	0.3-0.6	RAIN	3.5

Appendix 1. Continued.

STARTING DATE	TIME START	TIME FINISH	STATION	TEMPERATURE C SURFACE	TEMPERATURE C FISH DEPTH	WIND DIR. FROM	WIND SPEED MPH	WAVES DIR. FROM	WAVES HT. (M)	WEATHER	SECCHI DISC (M)
10-16-79	1920	0733	C	13.5	13.5	SW	5-10	SW	0.6-1.0	OVERCAST	___
10-16-79	0745	1705	C*	13.5	13.5	SE	0-5	SW	0.3-0.6	RAIN	3.5
10-16-79	1925	0726	C*	13.5	13.5	SW	5-10	SW	0.6-1.0	OVERCAST	___
10-16-79	0750	1715	D	13.8	13.0	SE	0-5	SW	0.3-0.6	RAIN	4.0
10-16-79	1910	0720	D	13.6	13.5	SW	5-10	SW	0.6-1.0	OVERCAST	___
10-16-79	0800	1722	E	13.8	13.4	SE	0-5	SW	0.3-0.6	RAIN	4.0
10-16-79	1900	0705	E	14.0	13.5	SW	5-10	SW	0.6-1.0	OVERCAST	___
10-16-79	0835	1645	L	13.4	13.0	ESE	0-5	SW	0.3-0.6	RAIN	3.2
10-16-79	1915	0715	L	13.7	13.2	WSW	5-10	SW	0.3-0.6	FOG	___
10-16-79	0825	1633	L*	13.4	13.4	ESE	0-5	SW	0.3-0.6	OVERCAST	3.2
10-16-79	1910	0722	L*	13.7	13.7	WSW	5-10	SW	0.3-0.6	FOG	___
10-16-79	0840	1654	U*	13.3	13.3	ESE	0-5	SW	0.3-0.6	RAIN	3.2
10-16-79	1922	0705	U*	13.6	13.6	WSW	5-10	SW	0.3-0.6	FOG	___
11-14-79	0855	1645	B	8.6	8.6	NW	10-15	NW	0.6-1.0	PT CLOUDY	___
11-15-79	2000	0855	B	7.0	6.2	NW	10-15	NW	1-2	PT CLOUDY	___
11-14-79	0910	1620	C	8.6	8.6	NW	10-15	NW	0.6-1.0	PT CLOUDY	___
11-15-79	2015	0845	C	7.2	7.2	NW	10-15	NW	1-2	PT CLOUDY	___
11-14-79	0915	1630	C*	8.6	8.6	NW	10-15	NW	0.6-1.0	PT CLOUDY	___
11-15-79	2005	0850	C*	7.2	7.2	NW	10-15	NW	1-2	PT CLOUDY	___
11-14-79	0920	1610	D	8.5	8.5	NW	15-20	NW	0.6-1.0	PT CLOUDY	___
11-15-79	2020	0835	D	7.8	7.8	NW	10-15	NW	1-2	PT CLOUDY	___
11-14-79	0930	1555	E	8.5	8.5	NW	15-20	NW	0.6-1.0	PT CLOUDY	___
11-15-79	2030	0825	E	7.8	7.8	NW	10-15	NW	1-2	PT CLOUDY	___
11-14-79	0815	1600	L	8.3	8.0	N	5-10	N	0.3-0.6	PT CLOUDY	2.5
11-15-79	1920	0740	L	8.5	6.9	NW	10-15	NW	1-2	PT CLOUDY	___
11-14-79	0825	1610	L*	8.3	8.3	N	5-10	N	0.3-0.6	PT CLOUDY	2.5
11-15-79	1925	0800	L*	8.5	8.5	NW	10-15	NW	1-2	PT CLOUDY	___
11-14-79	0805	1550	U	8.6	8.5	N	5-10	N	0.3-0.6	PT CLOUDY	2.5
11-15-79	1915	0720	U	7.2	6.8	NW	10-15	NW	1-2	PT CLOUDY	___
11-14-79	0810	1540	U*	8.6	8.6	N	5-10	N	0.3-0.6	PT CLOUDY	2.5
11-15-79	1905	0745	U*	7.2	7.2	NW	10-15	NW	1-2	PT CLOUDY	___

APPENDIX 2

Appendix 2. Physical and limnological parameters measured at the time seines were used.

Starting date	Time Start	Station	Temperature C Surface	Temperature C Fish depth	Wind Dir. from	Wind Speed mph	Waves Dir. from	Waves Ht. (m)	Weather
4-18-79	1625	P	10.0	10.0	NW	10-15	NW	0.3-0.6	CLEAR
4-17-79	2215	P	7.7	7.7	CALM	0-5	NW	0.3-0.6	CLEAR
4-18-79	1705	Q	9.0	9.0	NW	10-15	WNW	0.3-0.6	CLEAR
4-17-79	2300	Q	10.5	10.5	CALM	0-5	NW	0.3-0.6	CLEAR
4-18-79	1725	R	11.0	11.0	N	10-15	NW	0.3-0.6	CLEAR
4-17-79	2330	R	7.3	7.5	CALM	0-5	NW	0-0.3	CLEAR
4-18-79	1755	S	8.5	8.5	W	5-10	W	0-0.3	CLEAR
4-17-79	2125	S	6.6	6.6	CALM	0-5	CALM	0-0.3	CLEAR
4-18-79	1823	V	8.5	8.5	W	0-5	W	0-0.3	CLEAR
4-17-79	2104	V	8.5	8.5	CALM	0-5	CALM	0-0.3	CLEAR
5-14-79	1612	P	13.5	13.5	SW	0-5	SW	0-0.3	OVERCAST
5-14-79	2120	P	13.5	13.5	SW	0-5	SW	0-0.3	CLEAR
5-14-79	1650	Q	14.2	14.2	SW	0-5	SW	0-0.3	RAIN
5-14-79	2153	Q	13.0	13.0	SW	0-5	SW	0-0.3	CLEAR
5-14-79	1710	R	14.6	14.6	SW	0-5	SW	0-0.3	RAIN
5-14-79	2220	R	13.5	13.5	SW	0-5	SW	0-0.3	CLEAR
5-14-79	1523	S	13.0	13.0	SW	0-5	CALM	0-0.3	CLEAR
5-14-79	2320	S	12.6	12.6	SW	0-5	SW	0-0.3	CLEAR
5-14-79	1504	V	14.9	14.9	SW	0-5	CALM	0-0.3	CLEAR
5-14-79	2255	V	14.7	14.7	SW	0-5	SW	0-0.3	CLEAR
6-18-79	1334	P	15.5	13.5	E	0-5	SW	0-0.3	PT CLOUDY
6-18-79	2201	P	12.2	12.2	E	0-5	SW	0-0.3	CLEAR
6-18-79	1354	Q	13.0	12.9	E	0-5	SW	0-0.3	PT CLOUDY
6-18-79	2224	Q	13.0	12.9	E	0-5	SW	0-0.3	CLEAR
6-18-79	1427	R	15.2	14.6	E	0-5	W	0-0.3	PT CLOUDY
6-18-79	2248	R	13.0	13.0	E	0-5	SW	0-0.3	CLEAR
6-18-79	1453	S	16.4	17.0	E	0-5	SW	0-0.3	PT CLOUDY
6-18-79	2305	S	16.0	16.0	E	0-5	SW	0-0.3	CLEAR
6-18-79	1515	V	19.5	19.5	E	0-5	SW	0-0.3	PT CLOUDY
6-18-79	2345	V	18.0	18.0	E	0-5	SW	0-0.3	CLEAR
7-18-79	1533	P	14.5	14.2	N	0-5	NW	0-0.3	CLEAR
7-17-79	2222	P	11.0	11.0	NW	5-10	NW	0.3-0.6	CLEAR
7-18-79	1605	Q	14.0	12.5	N	0-5	NW	0-0.3	CLEAR
7-17-79	2302	Q	10.3	10.3	NW	0-5	NW	0.3-0.6	CLEAR
7-18-79	1630	R	16.8	15.4	N	0-5	NW	0-0.3	CLEAR
7-17-79	2332	R	13.5	13.5	NW	0-5	NW	0.3-0.6	CLEAR
7-16-79	1300	S	23.4	23.4	NW	10-15	NW	0-0.3	CLEAR
6-16-79	2237	S	21.3	21.3	NW	10-15	NW	0-0.3	CLEAR
7-16-79	1234	V	24.4	24.4	NW	10-15	NW	0-0.3	PT CLOUDY
7-16-79	2207	V	22.0	22.0	NW	10-15	CALM	0-0.3	CLEAR
8-20-79	1405	P	15.5	15.0	SW	0-5	SW	0-0.3	OVERCAST
8-20-79	2355	P	14.8	15.0	SE	0-5	NW	0-0.3	HAZE
8-20-79	1425	Q	15.0	14.5	NE	0-5	SW	0-0.3	OVERCAST
8-20-79	2240	Q	15.0	15.0	SE	0-5	NW	0-0.3	FOG
8-20-79	1445	R	14.5	14.5	NE	0-5	SW	0-0.3	RAIN

Appendix 2. Continued.

Starting date	Time Start	Station	Temperature C Surface	Temperature C Fish depth	Wind Dir. from	Wind Speed mph	Waves Dir. from	Waves Ht. (m)	Weather
8-20-79	2315	R	16.0	15.1	SE	0-5	NW	0-0.3	FOG
8-20-79	1535	S	15.5	15.5	NE	0-5	SW	0-0.3	RAIN
8-21-79	0035	S	15.2	15.0	SE	0-5	SW	0-0.3	FOG
8-20-79	1625	V	18.5	18.5	NE	0-5	SW	0-0.3	PT CLOUDY
8-21-79	0055	V	17.5	17.5	SE	0-5	SW	0-0.3	FOG
9-19-79	1352	P	14.5	14.7	NE	5-10	NW	0.6-1.0	CLEAR
9-19-79	1935	P	14.8	14.0	VAR	10-15	NW	0.3-0.6	CLEAR
9-19-79	1410	Q	14.8	14.6	NE	5-10	NW	0.3-0.6	CLEAR
9-19-79	2000	Q	16.0	15.0	VAR	10-15	NW	0.3-0.6	CLEAR
9-19-79	1435	R	14.5	14.7	NE	5-10	NW	0.3-0.6	CLEAR
9-19-79	2035	R	15.5	15.5	VAR	10-15	NW	0.3-0.6	CLEAR
9-17-79	1507	S	12.5	12.5	VAR	0-5	SW	0-0.3	CLEAR
9-17-79	2100	S	13.0	13.0	SW	0-5	SW	0-0.3	CLEAR
9-17-79	1423	V	18.2	18.2	SW	5-10	SW	0.3-0.6	CLEAR
9-17-79	2000	V	15.9	15.9	SW	0-5	SW	0-0.3	CLEAR
10-16-79	1422	P	13.2	13.2	ESE	0-5	SW	0-0.3	RAIN
10-16-79	2305	P	12.8	12.8	S	5-10	SW	0.3-0.6	RAIN
10-16-79	1442	Q	12.0	12.0	ESE	0-5	SW	0-0.3	RAIN
10-16-79	2334	Q	13.0	13.0	S	5-10	SW	0.3-0.6	RAIN
10-16-79	1459	R	12.8	12.8	ESE	0-5	SW	0.3-0.6	RAIN
10-17-79	0000	R	12.8	12.8	S	5-10	SW	0.3-0.6	RAIN
10-16-79	1348	S	13.6	12.3	ESE	0-5	NW	0-0.3	RAIN
10-16-79	2210	S	12.8	12.8	CALM	0-5	CALM	0-0.3	RAIN
10-16-79	1332	V	11.2	11.2	ESE	0-5	CALM	0-0.3	RAIN
10-16-79	2120	V	11.5	11.5	CALM	0-5	CALM	0-0.3	RAIN
11-07-79	1145	P	9.3	9.2	SW	15-20	WSW	1-2	OVERCAST
11-07-79	1830	P	8.0	8.0	SW	15-20	SW	1-2	OVERCAST
11-07-79	1208	Q	11.9	11.5	WSW	10-15	WSW	1-2	OVERCAST
11-07-79	1910	Q	9.3	9.3	SW	15-20	SW	1-2	PT CLOUDY
11-07-79	1230	R	8.5	8.0	WSW	10-15	WSW	1-2	OVERCAST
11-07-79	1915	R	11.4	11.4	SW	15-20	SW	1-2	PT CLOUDY
11-06-79	1140	S	9.8	9.8	NW	15-20	NW	0.3-0.6	RAIN
11-06-79	2020	S	9.0	9.0	NW	15-20	NW	0.3-0.6	OVERCAST
11-06-79	1215	V	8.4	8.4	N	10-15	N	0.3-0.6	RAIN
11-06-79	2000	V	8.0	8.0	NW	15-20	NW	0.3-0.6	OVERCAST

APPENDIX 3

Appendix 3. Physical and limnological parameters measured at the time trawling gear was used.

STARTING DATE	TIME START	TIME FINISH	STATION	TEMPERATURE C SURFACE	TEMPERATURE C FISH DEPTH	WIND DIR. FROM	WIND SPEED MPH	WAVES DIR. FROM	WAVES HT. (M)	WEATHER	SECCHI DISC (M)
4-18-79	1439	1449	B	5.5	4.2	NE	0-5	NW	0-0.3	CLEAR	2.0
4-18-79	1945	1955	B	5.0	5.0	NE	5-10	N	0-0.3	CLEAR	---
4-18-79	1526	1536	C	4.5	4.5	N	5-10	NW	0-0.3	CLEAR	2.5
4-18-79	2017	2027	C	4.0	4.0	NE	5-10	N	0-0.3	CLEAR	---
4-18-79	1545	1555	D	2.9	2.9	NNW	5-10	NW	0-0.3	CLEAR	3.0
4-18-79	2055	2105	D	2.5	2.5	NE	5-10	N	0-0.3	CLEAR	---
4-18-79	1620	1630	E	2.5	3.0	N	0-5	NW	0-0.3	CLEAR	2.8
4-18-79	2132	2142	E	2.0	2.0	NE	5-10	N	0-0.3	CLEAR	---
4-18-79	1700	1710	F	1.8	1.8	N	0-5	NW	0-0.3	CLEAR	3.5
4-18-79	2212	2222	F	1.5	1.5	NE	5-10	N	0-0.3	CLEAR	---
4-18-79	1350	1400	L	1.5	2.0	NE	0-5	NW	0-0.3	CLEAR	2.8
4-18-79	2345	2355	L	1.5	1.5	NE	0-5	N	0-0.3	CLEAR	---
4-18-79	1314	1324	N	2.0	2.0	NE	0-5	NW	0-0.3	CLEAR	2.2
4-18-79	2306	2316	N	1.0	1.5	NE	0-5	N	0-0.3	CLEAR	---
5-14-79	1448	1458	B	11.8	12.0	CALM	0-5	NW	0-0.3	OVERCAST	2.5
5-14-79	2015	2025	B	11.1	11.1	VAR	0-5	VAR	0-0.3	PT CLOUDY	---
5-14-79	1521	1531	C	12.0	11.2	CALM	0-5	SW	0-0.3	HAZE	2.5
5-14-79	2047	2057	C	11.0	10.5	CALM	0-5	VAR	0-0.3	OVERCAST	---
5-14-79	1555	1605	D	11.5	11.8	CALM	0-5	CALM	0-0.3	OVERCAST	2.25
5-14-79	2121	2131	D	11.5	11.2	NW	0-5	CALM	0-0.3	OVERCAST	---
5-14-79	1631	1641	E	11.2	11.2	SW	5-10	SW	0-0.3	RAIN	2.0
5-14-79	2157	2207	E	11.0	10.5	CALM	0-5	CALM	0-0.3	PT CLOUDY	---
5-14-79	1744	1754	F	10.0	9.0	SW	5-10	SW	0-0.3	RAIN	2.0
5-14-79	2237	2247	F	10.2	9.0	W	10-15	CALM	0-0.3	CLEAR	---
5-14-79	1358	1408	L	11.5	12.0	SW	5-10	SW	1-2	HAZE	2.5
5-15-79	0004	0014	L	11.2	11.2	CALM	0-5	CALM	0-0.3	CLEAR	---
5-14-79	1320	1330	N	11.5	11.5	SW	10-15	SW	0.3-0.6	HAZE	2.5
5-14-79	2328	2338	N	11.0	11.0	W	5-10	W	0-0.3	CLEAR	---
6-21-79	1517	1527	B	16.9	17.0	SW	0-5	SW	1-2	CLEAR	3.0
6-21-79	2047	2057	B	17.0	16.0	SW	5-10	SW	0.6-1.0	CLEAR	---
6-21-79	1608	1618	C	16.0	16.1	CALM	0-5	SW	1-2	CLEAR	3.0
6-21-79	2115	2125	C	15.8	15.9	SW	5-10	SW	0.6-1.0	CLEAR	---
6-21-79	1628	1638	D	16.0	15.0	SW	0-5	SW	1-2	CLEAR	3.75
6-21-79	2152	2202	D	15.4	15.2	SW	5-10	SW	1-2	CLEAR	---
6-21-79	1705	1715	E	16.0	14.8	SW	0-5	SW	1-2	CLEAR	4.0
6-21-79	2230	2240	E	14.8	15.0	SW	5-10	SW	1-2	CLEAR	---
6-21-79	1745	1755	F	15.2	14.2	SW	0-5	SW	1-2	CLEAR	4.75
6-21-79	2312	2322	F	14.9	15.0	SW	5-10	SW	1-2	CLEAR	---
6-21-79	1425	1435	L	16.0	16.0	SW	10-15	SW	2-3	CLEAR	3.0
6-21-79	0045	0055	L	15.9	15.9	SW	5-10	SW	1-2	CLEAR	---
6-21-79	1345	1355	N	15.6	15.7	SW	10-15	SW	2-3	CLEAR	3.0
6-22-79	0005	0015	N	16.0	15.3	SW	5-10	SW	1-2	CLEAR	---
7-17-79	1505	1515	B	9.2	9.2	N	10-15	NW	0.3-0.6	PT CLOUDY	2.0
7-17-79	2045	2055	B	7.0	4.8	NNE	0-5	NW	0.3-0.6	CLEAR	---
7-17-79	1537	1547	C	7.9	7.0	N	5-10	NW	0.3-0.6	PT CLOUDY	2.5

Appendix 3. Continued.

STARTING DATE	TIME START	TIME FINISH	STATION	TEMPERATURE C SURFACE	TEMPERATURE C FISH DEPTH	WIND DIR. FROM	WIND SPEED MPH	WAVES DIR. FROM	WAVES HT. (M)	WEATHER	SECCHI DISC (M)
7-17-79	2115	2125	C	6.0	4.7	NNE	0-5	NW	0.3-0.6	CLEAR	---
7-17-79	1610	1620	D	11.3	6.0	N	10-15	NW	0.3-0.6	CLEAR	2.5
7-17-79	2150	2200	D	5.8	4.0	NNE	5-10	NW	0.3-0.6	CLEAR	---
7-17-79	1650	1700	E	10.1	4.0	N	5-10	NW	0.3-0.6	CLEAR	2.1
7-17-79	2330	2240	E	7.8	4.0	NNE	0-5	NW	0-0.3	CLEAR	---
7-17-79	1730	1740	F	10.0	4.0	NNW	5-10	NW	0.3-0.6	CLEAR	2.9
7-17-79	2310	2320	F	6.9	4.0	NNE	0-5	NE	0-0.3	CLEAR	---
7-17-79	1415	1425	L	9.2	7.3	NW	5-10	NW	0.3-0.6	PT CLOUDY	2.5
7-18-79	0045	0055	L	7.8	4.0	NNE	0-5	NW	0-0.3	CLEAR	---
7-17-79	1335	1345	N	10.2	6.4	NW	5-10	NW	0.3-0.6	PT CLOUDY	2.5
7-18-79	0005	0015	N	7.0	4.5	NNE	0-5	NW	0-0.3	CLEAR	---
8-22-79	1515	1525	B	15.8	15.8	CALM	0-5	VAR	0-0.3	OVERCAST	BOTTOM
8-22-79	1945	1955	B	15.7	15.8	ESE	5-10	ESE	0-0.3	FOG	---
8-22-79	1548	1558	C	15.0	15.0	SE	0-5	VAR	0-0.3	OVERCAST	4.0
8-22-79	2018	2028	C	16.0	15.0	ESE	5-10	ESE	0-0.3	FOG	---
8-22-79	1621	1631	D	15.0	15.0	E	0-5	VAR	0-0.3	OVERCAST	4.5
8-22-79	2052	2102	D	16.0	15.5	E	5-10	ESE	0-0.3	FOG	---
8-22-79	1657	1707	E	15.2	15.0	E	5-10	ESE	0-0.3	OVERCAST	4.5
8-22-79	2129	2139	E	16.0	15.2	E	5-10	ESE	0-0.3	FOG	---
8-22-79	1740	1750	F	15.2	12.1	ESE	5-10	ESE	0-0.3	OVERCAST	6.5
8-22-79	2211	2221	F	15.5	12.5	SE	10-15	ESE	0-0.3	HAZE	---
8-22-79	1420	1430	L	15.2	15.0	CALM	0-5	SW	0-0.3	OVERCAST	3.0
8-22-79	2345	2355	L	16.0	16.0	SE	5-10	SE	0-0.3	HAZE	---
8-22-79	1338	1348	N	15.0	15.0	SE	5-10	SW	0-0.3	RAIN	3.0
8-22-79	2307	2317	N	16.0	15.2	SE	15	ESE	0-0.3	HAZE	---
9-25-79	1434	1444	B	13.8	13.5	CALM	0-5	W	1-2	CLEAR	BOTTOM
9-25-79	1904	1914	B	14.0	13.8	S	0-5	W	1-2	HAZE	---
9-25-79	1507	1517	C	13.5	12.0	CALM	0-5	W	1-2	CLEAR	4.0
9-25-79	1937	1947	C	13.0	11.2	CALM	0-5	W	1-2	HAZE	---
9-25-79	1544	1554	D	14.0	12.0	CALM	0-5	W	1-2	CLEAR	4.0
9-25-79	2013	2023	D	13.9	11.4	CALM	0-5	CALM	0-0.3	HAZE	---
9-25-79	1622	1632	E	13.9	10.2	SW	0-5	W	1-2	CLEAR	4.5
9-25-79	2054	2104	E	14.0	10.0	SE	0-5	CALM	0-0.3	CLEAR	---
9-25-79	1701	1711	F	14.0	9.5	SW	0-5	W	1-2	CLEAR	4.2
9-25-79	2133	2143	F	14.0	10.0	S	5-10	CALM	0-0.3	CLEAR	---
9-25-79	1338	1348	L	14.9	12.0	W	5-10	W	1-2	CLEAR	3.0
9-25-79	2311	2321	L	15.0	13.0	SE	0-5	CALM	0-0.3	HAZE	---
9-25-79	1257	1307	N	14.9	11.2	WNW	0-5	W	1-2	CLEAR	4.0
9-25-79	2232	2242	N	15.0	11.8	SE	0-5	CALM	0-0.3	HAZE	---
10-16-79	0746	0756	B	13.2	13.5	E	5-10	SW	0.3-0.6	RAIN	3.0
10-15-79	1903	1913	B	11.5	11.2	S	0-5	SW	0-0.3	PT CLOUDY	---
10-16-79	0826	0836	C	13.5	13.6	SE	5-10	SW	0.3-0.6	RAIN	3.9
10-15-79	1924	1934	C	12.0	11.5	S	0-5	SW	0-0.3	PT CLOUDY	---
10-16-79	0900	0910	D	13.8	13.0	SE	5-10	SW	0.3-0.6	RAIN	4.5
10-15-79	2011	2021	D	12.5	12.0	S	5-10	SW	0-0.3	PT CLOUDY	---

Appendix 3. Continued.

STARTING DATE	TIME START	TIME FINISH	STATION	TEMPERATURE C SURFACE	TEMPERATURE C FISH DEPTH	WIND DIR. FROM	WIND SPEED MPH	WAVES DIR. FROM	WAVES HT. (M)	WEATHER	SECCHI DISC (M)
10-16-79	0938	0948	E	13.8	13.4	SE	5-10	SW	0.3-0.6	HAZE	5.2
10-15-79	2048	2058	E	12.9	12.5	S	0-5	SW	0-0.3	PT CLOUDY	---
10-16-79	1017	1027	F	14.0	13.4	SSE	5-10	SW	0-0.3	RAIN	6.5
10-15-79	2130	2140	F	13.0	12.8	SSE	0-5	SW	0-0.3	CLEAR	---
10-16-79	1113	1123	L	11.0	11.0	SW	15-20	SW	1-2	CLEAR	2.0
10-15-79	2300	2310	L	13.0	12.3	SE	5-10	SW	0-0.3	PT CLOUDY	---
10-15-79	1028	1038	N	11.2	11.2	SW	15-20	SW	1-2	CLEAR	2.0
10-15-79	2225	2235	N	13.0	12.5	SE	5-10	SW	0-0.3	PT CLOUDY	---
11-05-79	1802	1812	B	10.3	10.3	SSE	0-5	SW	0.3-0.6	PT CLOUDY	---
11-05-79	1250	1300	C	10.1	10.1	SSW	15-20	WSW	1-2	CLEAR	2.25
11-05-79	1837	1847	C	10.2	10.4	SE	5-10	SW	0.3-0.6	OVERCAST	---
11-05-79	1327	1337	D	10.8	10.8	SSW	15-20	SW	1-2	CLEAR	2.5
11-05-79	1914	1924	D	10.7	11.0	ESE	10-15	SW	0.3-0.6	PT CLOUDY	---
11-05-79	1410	1420	E	10.8	11.0	SSW	15-20	SW	1-2	CLEAR	2.75
11-05-79	1954	2004	E	11.0	11.0	ESE	10-15	SW	0.3-0.6	PT CLOUDY	---
11-05-79	1455	1505	F	11.0	11.4	SSW	10-15	SW	1-2	CLEAR	---
11-05-79	2035	2045	F	11.0	11.3	ESE	10-15	S	0.3-0.6	PT CLOUDY	---
11-05-79	1127	1137	L	10.4	10.4	S	15-20	SW	1-2	CLEAR	2.5
11-05-79	2208	2218	L	10.2	11.0	SE	5-10	S	0-0.3	PT CLOUDY	---
11-05-79	1045	1055	N	10.8	10.8	S	10-15	SW	1-2	PT CLOUDY	2.75
11-05-79	2130	2140	N	11.0	11.0	SE	5-10	S	0-0.3	PT CLOUDY	---
12-13-79	1015	1025	B	2.0	2.0	E	10-15	E	0.6-1.0	CLEAR	0.75
12-12-79	1735	1745	B	3.5	2.7	NE	10-15	NW	0.6-1.0	OVERCAST	---
12-13-79	1050	1100	C	4.0	4.0	E	5-10	NE	0.3-0.6	CLEAR	1.0
12-12-79	1810	1820	C	4.0	4.0	NE	5-10	NW	0.6-1.0	OVERCAST	---
12-13-79	1125	1135	D	4.0	4.0	E	0-5	NE	0.3-0.6	PT CLOUDY	1.0
12-12-79	1845	1855	D	4.0	4.0	NE	5-10	NW	0.6-1.0	OVERCAST	---
12-12-79	1615	1625	E	4.0	4.0	NE	10-15	NE	1-2	OVERCAST	1.0
12-12-79	1925	1935	E	5.0	5.0	NE	5-10	NW	0.6-1.0	OVERCAST	---
12-12-79	1525	1535	F	4.5	4.0	NNE	10-15	NE	1-2	SNOW	1.25
12-12-79	2005	2015	F	4.0	4.0	NE	5-10	NW	0.3-0.6	OVERCAST	---
12-12-79	1435	1445	L	4.0	4.0	N	15-20	NW	1-2	SNOW	0.75
12-12-79	2150	2200	L	4.0	4.0	NE	5-10	NW	0.3-0.6	OVERCAST	---
12-12-79	1400	1410	N	4.0	4.0	N	20-25	NW	1-2	SNOW	1.0
12-12-79	2130	2140	N	4.0	4.0	NE	5-10	NW	0.3-0.6	OVERCAST	---

APPENDIX 4

Appendix 4. Physical and limnological parameters measured at the time plankton net tows were performed.

STARTING DATE	STARTING TIME	STATION	DIEL PERIOD	SECCHI DISC (M)	TEMPERATURE C SURFACE	TEMPERATURE C MID DEPTH	TEMPERATURE C BOTTOM	WIND DIR. FROM	WIND SPEED (MPH)	WAVES DIR. FROM	WAVES HT. (M)	WEATHER
4-17-79	1543	A	D	1.2	8.4	8.4	8.4	NW	15-20	NW	0.6	CLEAR
4-16-79	2120	A	N	-	7.0	7.0	7.0	NW	5-10	NW	0.3-0.6	CLEAR
4-17-79	1556	B	D	1.2	7.8	7.8	7.8	NW	15-20	NW	0.6	CLEAR
4-16-79	2129	B	N	-	7.5	7.5	7.5	NW	5-10	NW	0.3-0.6	CLEAR
4-16-79	1721	C	D	2.5	4.6	4.6	4.6	WNW	10-15	NW	0.6-1.0	PT CLOUDY
4-16-79	1946	C	N	-	5.0	5.0	4.6	NNW	0-5	NNW	0.6	CLEAR
4-16-79	1645	D	D	3.0	2.5	3.0	3.0	NW	10-15	NW	1.0	CLEAR
4-16-79	2014	D	N	-	2.0	2.0	2.0	NW	5-10	NW	0.6	CLEAR
4-16-79	1608	E	D	3.5	2.5	2.5	3.0	NW	10-15	NW	1.0	CLEAR
4-16-79	2053	E	N	-	2.5	2.5	2.5	N	0-5	NW	0.6	CLEAR
4-16-79	1541	F	D	3.5	2.5	2.5	2.5	NW	15-20	NW	1.0	CLEAR
4-16-79	2133	F	N	-	2.5	2.5	3.0	NNE	0-5	NW	0.6	CLEAR
4-17-79	1640	I	D	1.0	8.6	8.6	9.6	NW	15-20	NW	0.6	CLEAR
4-16-79	2250	I	N	-	9.3	8.3	8.3	NW	5-10	NW	0.3-0.6	CLEAR
4-17-79	1655	J	D	1.0	8.4	8.0	8.0	NW	15-20	NW	0.6	CLEAR
4-16-79	2308	J	N	-	7.5	9.2	9.2	NW	5-10	NW	0.3-0.6	CLEAR
4-17-79	1711	L	D	2.5	3.5	3.5	3.8	NNW	5-10	NW	0.6	CLEAR
4-17-79	1947	L	N	-	2.5	2.5	3.0	N	5-10	NW	0.6	CLEAR
4-18-79	1115	M	D	1.25	7.8	7.3	7.0	NNE	5-10	W	0-0.3	CLEAR
4-20-79	0030	M	N	-	9.5	7.0	6.5	E	5-10	CALM	CALM	CLEAR
4-17-79	1629	N	D	2.5	2.5	2.5	2.5	NNW	5-10	NW	0.6	CLEAR
4-17-79	2017	N	N	-	2.0	2.3	2.3	N	5-10	NW	0.6	CLEAR
4-17-79	1553	O	D	3.0	2.3	2.3	2.3	NNW	5-10	NW	0.6-1.0	CLEAR
4-17-79	2055	O	N	-	1.5	1.9	2.0	NE	5-10	NW	0.3	CLEAR
4-18-79	1635	P	D	BOTTOM	10.0	10.0	10.0	NW	10-15	NW	0.3-0.6	CLEAR
4-18-79	2012	P	N	-	8.0	7.7	7.7	CALM	0-5	NW	0.3-0.6	CLEAR
4-18-79	1710	Q	D	BOTTOM	9.0	9.0	8.5	NW	10-15	NW	0.3-0.6	CLEAR
4-18-79	2050	Q	N	-	6.6	6.6	6.6	CALM	0-5	NW	0.3-0.6	CLEAR
4-18-79	1735	R	D	BOTTOM	11.0	11.0	10.5	NW	10-15	NW	0.3-0.6	CLEAR
4-17-79	2340	R	N	-	7.5	7.3	7.3	CALM	0-5	NW	0.3-0.6	CLEAR
4-18-79	1810	S	D	BOTTOM	8.5	8.5	8.5	NW	10-15	WNW	0.3-0.6	CLEAR
4-17-79	2140	S	N	-	6.6	6.6	6.6	CALM	0-5	CALM	CALM	CLEAR
4-18-79	1825	V	D	BOTTOM	8.5	8.5	8.5	NW	10-15	WNW	0.3-0.6	CLEAR
4-17-79	2115	V	N	-	8.5	8.5	8.5	CALM	0-5	CALM	CALM	CLEAR
4-17-79	1527	W	D	2.75	2.3	2.3	2.1	NNW	10-15	NW	0.6-1.0	HAZE
4-17-79	2132	W	N	-	1.1	1.1	1.5	N	0-5	NNW	0.3	CLEAR
4-18-79	1125	X	D	1.0	10.6	10.6	10.6	NNE	5-10	W	0-0.3	CLEAR
4-20-79	0016	X	N	-	11.0	11.0	7.5	E	5-10	CALM	CALM	CLEAR
4-18-79	1145	Z	D	1.3	7.2	7.4	7.4	NNE	5-10	CALM	CALM	CLEAR
4-19-79	2302	Z	N	-	5.5	5.5	7.0	E	5-10	CALM	CALM	CLEAR
5-15-79	1120	A	D	1.5	13.0	13.0	12.5	NW	5-10	NW	0.3-0.6	HAZE
5-16-79	2215	A	N	-	13.0	13.0	13.0	ESE	0-5	CALM	CALM	CLEAR
5-15-79	1153	B	D	3.0	12.6	12.6	12.3	NW	5-10	NW	0.3-0.6	HAZE
5-16-79	2225	B	N	-	13.0	13.0	11.5	ESE	0-5	CALM	CALM	CLEAR
5-15-79	1707	C	D	2.5	13.0	12.8	12.5	NW	0-5	NW	0-0.3	CLEAR

Appendix 4. Continued.

STARTING DATE	STARTING TIME	STATION	DIEL PERIOD	SECCHI DISC (M)	TEMPERATURE C SURFACE	MID DEPTH	BOTTOM	WIND DIR. FROM	SPEED (MPH)	WAVES DIR. FROM	HT. (M)	WEATHER
5-15-79	2015	C	N	-	11.0	10.0	10.0	NW	0-5	NW	0-0.3	CLEAR
5-15-79	1630	D	D	2.3	13.0	11.5	11.2	NW	0-5	NW	0-0.3	CLEAR
5-15-79	2042	D	N	-	11.2	9.5	9.5	CALM	0-5	NW	0-0.3	CLEAR
5-15-79	1552	E	D	2.5	13.0	11.5	11.0	NW	0-5	NW	0.3	CLEAR
5-15-79	2118	E	N	-	10.8	9.6	9.0	CALM	0-5	NW	0-0.3	CLEAR
5-15-79	1528	F	D	3.0	12.0	11.8	11.5	NW	0-5	NW	0.3-0.6	CLEAR
5-15-79	2157	F	N	-	11.2	8.2	8.0	CALM	0-5	NW	0-0.3	CLEAR
5-15-79	1213	I	D	1.8	13.5	13.5	13.5	NW	5-10	NW	0.3-0.6	HAZE
5-16-79	2100	I	N	-	13.4	13.0	12.0	SE	0-5	CALM	CALM	CLEAR
5-15-79	1228	J	D	2.0	13.3	13.3	13.0	NW	5-10	NW	0.3-0.6	HAZE
5-16-79	2109	J	N	-	12.7	12.7	12.7	SE	0-5	CALM	CALM	CLEAR
5-16-79	0815	L	D	0.9	12.9	11.9	10.9	NE	5-10	VAR	0-0.1	CLEAR
5-16-79	0057	L	N	-	12.5	12.0	11.8	NW	0-5	NW	0-0.3	CLEAR
5-15-79	1320	M	D	3.5	13.1	12.6	12.6	NW	5-10	CALM	CALM	HAZE
5-16-79	2154	M	N	-	13.8	12.5	12.3	SE	0-5	CALM	CALM	CLEAR
5-16-79	0849	N	D	1.2	11.6	10.8	10.6	NE	5-10	VAR	0-0.1	CLEAR
5-16-79	0028	N	N	-	11.2	10.2	9.5	NW	0-5	NW	0-0.3	CLEAR
5-16-79	0917	O	D	1.5	11.2	10.0	10.2	SE	5-10	VAR	0-0.1	CLEAR
5-15-79	2324	O	N	-	11.0	9.5	9.5	NW	0-5	NW	0-0.3	CLEAR
5-14-79	1612	P	D	BOTTOM	13.5	13.5	13.5	SW	5-10	SW	0.3	OVERCAST
5-14-79	2120	P	N	-	13.5	13.5	13.5	SW	0-5	SW	0.3	CLEAR
5-14-79	1642	Q	D	BOTTOM	14.2	14.2	14.2	SW	5-10	SW	0.3	CLEAR
5-14-79	2153	Q	N	-	13.0	13.0	13.0	SW	0-5	SW	0.3	CLEAR
5-14-79	1707	R	D	BOTTOM	14.6	14.6	14.6	SW	5-10	SW	0.3	OVERCAST
5-14-79	2220	R	N	-	13.5	13.5	13.5	SW	0-5	SW	0.3	CLEAR
5-14-79	1523	S	D	BOTTOM	13.0	13.0	13.0	NW	0-5	CALM	CALM	PT CLOUDY
5-14-79	2330	S	N	-	12.6	12.6	12.6	SW	0-5	SW	0-0.3	CLEAR
5-14-79	1505	V	D	BOTTOM	14.9	14.9	14.9	NW	0-5	CALM	CALM	PT CLOUDY
5-14-79	2255	V	N	-	14.7	14.7	14.7	SW	0-5	SW	0-0.3	CLEAR
5-16-79	0947	W	D	2.5	12.2	11.0	10.8	NE	0-5	SE	0-0.1	CLEAR
5-15-79	2246	W	N	-	12.0	9.8	9.5	NW	0-5	NW	0-0.3	CLEAR
5-15-79	1246	X	D	3.5	14.3	12.8	12.3	NW	5-10	CALM	CALM	HAZE
5-16-79	2220	X	N	-	15.0	12.5	12.2	SE	0-5	CALM	CALM	CLEAR
5-15-79	1337	Z	D	2.5	13.6	12.9	12.8	NW	5-10	NW	0.3-0.6	CLEAR
5-16-79	2135	Z	N	-	12.6	12.6	12.6	SE	0-5	CALM	CALM	CLEAR
6-05-79	1217	A	D	1.5	13.5	12.0	12.0	VAR	0-5	NW	0-0.3	PT CLOUDY
6-04-79	2105	A	N	-	14.0	14.0	14.0	S	0-5	SW	0-0.3	PT CLOUDY
6-05-79	1510	B	D	2.2	12.5	11.3	11.3	VAR	0-5	NW	0-0.3	PT CLOUDY
6-04-79	2117	B	N	-	13.5	13.5	12.5	S	0-5	SW	0-0.3	PT CLOUDY
6-05-79	1639	C	D	4.5	11.0	10.9	10.9	N	5-10	N	0.3-0.6	PT CLOUDY
6-05-79	2030	C	N	-	10.0	10.0	10.5	NNW	5-10	W	0.6	OVERCAST
6-05-79	1601	D	D	4.0	11.5	10.5	10.2	N	5-10	N	0.3-0.6	PT CLOUDY
6-05-79	2055	D	N	-	10.5	9.8	9.8	N	0-5	NW	0.6-1.0	PT CLOUDY
6-05-79	1538	E	D	4.0	11.8	10.5	10.5	N	0-5	N	0.6	PT CLOUDY
6-05-79	2132	E	N	-	11.0	10.2	9.0	N	0-5	NW	0.6-1.0	PT CLOUDY

Appendix 4. Continued.

STARTING DATE	STARTING TIME	STATION	DIEL PERIOD	SECCHI DISC (M)	TEMPERATURE C SURFACE	TEMPERATURE C MID DEPTH	TEMPERATURE C BOTTOM	WIND DIR. FROM	WIND SPEED (MPH)	WAVES DIR. FROM	WAVES HT. (M)	WEATHER
6-05-79	1500	F	D	3.5	11.5	10.0	9.5	N	5-10	N	0.6-1.0	PT CLOUDY
6-05-79	2209	F	N	-	10.5	9.0	9.0	N	5-10	NW	0.6-1.0	PT CLOUDY
6-05-79	1736	I	D	1.5	14.0	13.5	13.5	VAR	0-5	NW	0-0.3	PT CLOUDY
6-04-79	2323	I	N	-	13.5	13.5	13.0	S	0-5	SW	0-0.3	PT CLOUDY
6-05-79	1717	J	D	1.8	13.5	13.0	13.0	VAR	0-5	NW	0-0.3	PT CLOUDY
6-04-79	2302	J	N	-	13.5	13.0	11.5	S	0-5	SW	0-0.3	PT CLOUDY
6-05-79	1420	L	D	3.0	12.0	11.2	11.3	N	0-5	N	0.3	PT CLOUDY
6-06-79	0113	L	N	-	10.0	10.0	10.0	E	5-10	NW	0.3	CLEAR
6-04-79	1839	M	D	2.0	15.5	14.5	14.0	SW	10-15	CALM	CALM	PT CLOUDY
6-05-79	0048	M	N	-	14.5	14.0	13.5	S	0-5	SW	0-0.3	RAIN
6-05-79	1349	N	D	3.0	11.5	10.8	11.0	N	0-5	N	0.3	PT CLOUDY
6-06-79	0043	N	N	-	10.0	10.0	9.9	E	5-10	NW	0.3-0.6	CLEAR
6-05-79	1307	O	D	2.5	11.8	10.5	10.5	N	5-10	N	0.3	PT CLOUDY
6-05-79	0006	O	N	-	10.2	9.2	9.8	E	10-15	NW	0.6-1.0	CLEAR
6-05-79	1205	P	D	BOTTOM	13.5	12.0	12.0	VAR	0-5	NW	0-0.3	PT CLOUDY
6-05-79	2040	P	N	-	13.5	13.5	13.5	S	0-5	SW	0-0.3	PT CLOUDY
6-05-79	1815	Q	D	BOTTOM	13.5	13.0	13.0	VAR	0-5	NW	0-0.3	PT CLOUDY
6-05-79	0010	Q	N	-	13.0	13.0	13.0	S	0-5	SW	0-0.3	PT CLOUDY
6-05-79	1800	R	D	BOTTOM	14.0	13.5	13.5	VAR	0-5	NW	0-0.3	PT CLOUDY
6-05-79	2340	R	N	-	13.0	13.0	13.0	S	0-5	SW	0-0.3	PT CLOUDY
6-05-79	1830	S	D	2.0	15.0	15.0	15.0	NW	0-5	CALM	CALM	CLEAR
6-04-79	2213	S	N	-	13.0	12.9	12.9	VAR	0-5	CALM	CALM	PT CLOUDY
6-05-79	1915	V	D	BOTTOM	17.5	17.5	17.5	NW	0-5	CALM	CALM	CLEAR
6-04-79	2127	V	N	-	16.5	16.5	16.4	VAR	0-5	CALM	CALM	PT CLOUDY
6-05-79	1150	W	D	2.5	11.0	9.9	9.9	NE	0-5	N	0.3	PT CLOUDY
6-05-79	2258	W	N	-	11.0	9.0	7.9	E	0-5	NW	0.6-1.0	CLEAR
6-05-79	1906	X	D	2.0	18.0	18.0	18.0	SW	10-15	CALM	CALM	PT CLOUDY
6-05-79	0058	X	N	-	17.0	17.0	17.0	S	0-5	SW	0-0.3	RAIN
6-04-79	1629	Z	D	1.5	13.2	13.5	13.7	SW	10-15	CALM	CALM	PT CLOUDY
6-05-79	0122	Z	N	-	14.5	13.0	13.0	S	0-5	SW	0-0.3	RAIN
6-19-79	1338	A	D	BOTTOM	11.4	11.4	11.7	SE	10-15	SE	0.3-0.6	PT CLOUDY
6-20-79	0100	A	N	-	13.0	13.0	13.0	SE	0-5	SE	0.3	CLEAR
6-19-79	1411	B	D	BOTTOM	13.9	13.9	12.3	SE	10-15	SE	0.3-0.6	PT CLOUDY
6-20-79	0048	B	N	-	13.0	13.0	13.0	SE	0-5	SE	0.3	CLEAR
6-18-79	1802	C	D	4.5	15.5	15.0	15.0	E	5-10	CALM	CALM	CLEAR
6-18-79	2050	C	N	-	15.0	15.0	15.0	ENE	0-5	CALM	CALM	PT CLOUDY
6-18-79	1726	D	D	5.0	16.0	16.0	16.0	ENE	5-10	CALM	CALM	PT CLOUDY
6-18-79	2112	D	N	-	15.0	14.5	14.0	ENE	0-5	CALM	CALM	PT CLOUDY
6-18-79	1648	E	D	4.2	15.2	15.0	15.0	ENE	10-15	ENE	0-0.1	OVERCAST
6-18-79	2148	E	N	-	14.5	12.2	12.0	ENE	0-5	CALM	CALM	PT CLOUDY
6-18-79	1604	F	D	4.5	15.5	15.0	15.0	ENE	5-10	E	0-0.3	OVERCAST
6-18-79	2226	F	N	-	15.0	15.0	12.0	ENE	10-15	NE	0-0.1	PT CLOUDY
6-19-79	1616	I	D	0.5	13.0	13.0	13.0	SE	10-15	SE	0.3-0.6	PT CLOUDY
6-19-79	2236	I	N	-	13.0	13.0	12.7	SE	0-5	SE	0.3	CLEAR
6-19-79	1626	J	D	0.5	13.0	13.0	13.0	SE	10-15	SE	0.3-0.6	PT CLOUDY

Appendix 4. Continued.

STARTING DATE	STARTING TIME	STATION	DIEL PERIOD	SECCHI DISC (M)	TEMPERATURE C SURFACE	MID DEPTH	BOTTOM	WIND DIR. FROM	SPEED (MPH)	WAVES DIR. FROM	HT. (M)	WEATHER
6-19-79	2212	J	N	-	13.6	13.2	12.7	SE	0-5	SE	0.3	CLEAR
6-19-79	1737	L	D	2.0	16.2	16.2	16.5	SE	10-15	SE	0.3	CLEAR
6-19-79	2040	L	N	-	16.5	16.0	16.0	SE	10-15	S	0.3	CLEAR
6-20-79	1342	M	D	1.5	15.0	14.5	14.2	SSE	0-5	CALM	CALM	OVERCAST
6-20-79	0008	M	N	-	14.2	14.2	14.0	SW	5-10	SW	0-0.3	OVERCAST
6-19-79	1701	N	D	3.0	16.0	16.0	16.2	SE	15-20	SE	0.5	CLEAR
6-19-79	2109	N	N	-	16.0	16.0	16.0	SE	5-10	SW	0-0.3	PT CLOUDY
6-19-79	1623	O	D	3.5	17.5	17.5	15.8	SE	15-20	SE	0.6	CLEAR
6-19-79	2146	O	N	-	17.1	16.0	16.0	SE	15-20	SSW	0-0.3	PT CLOUDY
6-20-79	1517	P	D	BOTTOM	16.5	16.5	16.8	SE	15-20	SW	1.0	PT CLOUDY
6-20-79	2139	P	N	-	16.0	16.0	16.0	SSE	25+	SW	1-2	PT CLOUDY
6-20-79	1554	Q	D	BOTTOM	16.5	16.5	16.5	SE	15-20	SW	1.0	PT CLOUDY
6-20-79	2209	Q	N	-	14.2	14.2	14.2	SSE	25+	SW	1-2	PT CLOUDY
6-20-79	1215	R	D	BOTTOM	15.5	15.5	15.5	SE	15-20	SW	1.0	PT CLOUDY
6-20-79	2233	R	N	-	15.3	15.3	15.3	SSE	25+	SW	1-2	PT CLOUDY
6-20-79	1250	S	D	BOTTOM	14.4	14.4	14.4	SE	10-15	SE	0-0.3	PT CLOUDY
6-20-79	0046	S	N	-	14.6	14.6	14.6	S	20-25	S	0-0.3	PT CLOUDY
6-20-79	1307	V	D	BOTTOM	17.5	17.5	17.5	SE	10-15	SE	0-0.3	PT CLOUDY
6-20-79	0029	V	N	-	16.3	16.3	16.3	S	20-25	S	0-0.3	PT CLOUDY
6-19-79	1542	W	D	3.0	17.8	15.0	12.0	SE	15-20	SE	0.6	PT CLOUDY
6-19-79	2225	W	N	-	16.0	14.5	13.5	SE	15-20	SE	0.6	PT CLOUDY
6-20-79	1320	X	D	1.5	17.0	15.3	15.3	SSE	0-5	CALM	CALM	OVERCAST
6-20-79	0019	X	N	-	16.3	16.3	16.3	SW	5-10	SW	0-0.3	OVERCAST
6-20-79	1417	Z	D	1.5	15.5	15.0	15.0	SSE	0-5	CALM	CALM	OVERCAST
6-20-79	2341	Z	N	-	15.0	15.0	15.0	SW	5-10	SW	0-0.3	OVERCAST
7-02-79	1535	A	D	1.5	11.0	11.0	10.0	NW	0-5	NW	0.3	CLEAR
7-02-79	0008	A	N	-	9.5	8.5	8.0	SW	0-5	CALM	CALM	PT CLOUDY
7-02-79	1515	B	D	2.0	9.9	8.0	7.5	NW	0-5	NW	0.3	CLEAR
7-02-79	2358	B	N	-	9.5	7.5	7.5	SW	0-5	CALM	CALM	PT CLOUDY
7-02-79	1810	C	D	2.0	9.5	7.0	7.0	N	0-5	NW	0.6	CLEAR
7-02-79	2225	C	N	-	8.5	6.0	6.0	CALM	0-5	NW	0.3	CLEAR
7-02-79	1735	D	D	3.0	10.0	7.0	7.0	WNW	0-5	NW	0.6	CLEAR
7-02-79	2150	D	N	-	9.0	5.0	5.0	CALM	0-5	NW	0.3	CLEAR
7-02-79	1700	E	D	2.5	10.0	7.4	6.5	NW	5-10	NW	0.6	CLEAR
7-02-79	2110	E	N	-	9.0	5.0	5.0	CALM	0	NW	0.3	CLEAR
7-02-79	1620	F	D	3.0	9.9	7.0	6.9	NW	5-10	NW	0.6	CLEAR
7-02-79	2105	F	N	-	9.0	6.0	6.0	N	0-5	NW	0-0.3	CLEAR
7-02-79	1735	I	D	1.5	9.6	7.3	7.3	NW	0-5	NW	0.3	CLEAR
7-03-79	0220	I	N	-	9.6	8.9	8.5	SW	0-5	CALM	CALM	PT CLOUDY
7-02-79	1725	J	D	2.0	9.3	8.0	6.5	NW	0-5	NW	0.3	CLEAR
7-03-79	0240	J	N	-	9.5	7.2	7.2	SW	0-5	CALM	CALM	PT CLOUDY
7-03-79	1541	L	D	1.5	11.0	10.0	10.0	NW	0-5	NW	0-0.3	CLEAR
7-03-79	2048	L	N	-	10.0	9.0	9.0	SE	5-10	S	0-0.3	OVERCAST
7-03-79	1500	M	D	1.7	16.5	14.0	12.0	W	0-5	CALM	CALM	PT CLOUDY
7-03-79	0015	M	N	-	15.0	12.5	11.8	CALM	CALM	CALM	CALM	RAIN

Appendix 4. Continued.

STARTING DATE	STARTING TIME	STATION	DIEL PERIOD	SECCHI DISC (M)	TEMPERATURE C SURFACE	MID DEPTH	BOTTOM	WIND DIR. FROM	SPEED (MPH)	WAVES DIR. FROM	HT. (M)	WEATHER
7-03-79	1613	N	D	1.76	11.0	9.0	9.2	S	5-10	NNE	0-0.3	CLEAR
7-03-79	2056	N	N	-	10.0	8.3	8.0	ENE	10-15	E	0-0.3	RAIN
7-03-79	1649	O	D	2.0	10.0	8.0	8.0	N	5-10	NW	0-0.3	CLEAR
7-03-79	2133	O	N	-	9.5	8.0	8.0	E	10-15	E	0-0.3	RAIN
7-02-79	1600	P	D	BOTTOM	12.7	12.7	12.7	NW	5-10	NW	0.6-1.0	CLEAR
7-03-79	0025	P	N	-	10.0	10.0	10.0	SW	0-5	SW	0-0.3	PT CLOUDY
7-02-79	1755	Q	D	BOTTOM	11.0	11.0	11.0	NW	5-10	NW	0.6-1.0	CLEAR
7-03-79	0130	Q	N	-	9.6	9.6	9.6	SW	0-5	SW	0-0.3	PT CLOUDY
7-02-79	1745	R	D	BOTTOM	12.4	12.4	12.4	NW	5-10	NW	0.6-1.0	CLEAR
7-03-79	0215	R	N	-	10.0	10.0	10.0	SW	0-5	SW	0-0.3	PT CLOUDY
7-03-79	1550	S	D	BOTTOM	16.4	16.4	16.4	W	0-5	CALM	CALM	PT CLOUDY
7-04-79	0045	S	N	-	15.0	15.0	15.0	CALM	CALM	CALM	CALM	RAIN
7-03-79	1528	V	D	BOTTOM	21.2	21.2	20.5	W	0-5	CALM	CALM	PT CLOUDY
7-04-79	0033	V	N	-	15.0	18.0	18.0	CALM	CALM	CALM	CALM	RAIN
7-03-79	1729	W	D	2.5	11.0	8.3	8.3	N	0-5	CALM	CALM	CLEAR
7-03-79	2212	W	N	-	9.0	7.4	7.4	SE	10-15	S	0.3	RAIN
7-03-79	1535	X	D	1.2	21.5	20.0	19.5	W	0-5	CALM	CALM	PT CLOUDY
7-04-79	0025	X	N	-	15.0	15.0	13.4	CALM	CALM	CALM	CALM	RAIN
7-03-79	1600	Z	D	1.2	18.5	15.0	15.0	W	0-5	CALM	CALM	PT CLOUDY
7-03-79	2333	Z	N	-	14.5	14.5	14.0	CALM	CALM	CALM	CALM	RAIN
7-17-79	1121	A	D	1.5	14.0	13.0	13.0	NE	10-15	NE	0.5	OVERCAST
7-18-79	2132	A	N	-	13.0	9.3	9.4	CALM	CALM	NW	0-0.1	PT CLOUDY
7-17-79	1113	B	D	1.5	10.1	7.8	7.8	NE	10-15	NE	0.5	OVERCAST
7-18-79	2156	B	N	-	12.0	8.5	7.3	CALM	CALM	NW	0-0.1	PT CLOUDY
7-17-79	1755	C	D	2.5	9.5	5.0	5.0	S	0-5	CALM	CALM	CLEAR
7-18-79	2130	C	N	-	8.0	4.0	4.0	CALM	CALM	CALM	CALM	CLEAR
7-18-79	1720	D	D	1.5	10.0	4.0	4.5	SW	0-5	CALM	CALM	CLEAR
7-13-79	2150	D	N	-	7.0	4.0	4.0	CALM	CALM	CALM	CALM	CLEAR
7-18-79	1650	E	D	2.0	8.5	4.0	4.0	N	0-5	W	0-0.3	CLEAR
7-18-79	2165	E	N	-	8.0	4.0	4.0	CALM	CALM	CALM	CALM	CLEAR
7-18-79	1620	F	D	3.75	9.0	4.0	4.0	N	0-5	W	0-0.3	CLEAR
7-18-79	2055	F	N	-	6.5	4.0	4.0	CALM	CLAM	CALM	CALM	CLEAR
7-17-79	1314	I	D	0.5	11.4	11.5	11.5	NE	10-15	NE	0.5	OVERCAST
7-18-79	2324	I	N	-	11.7	9.5	8.9	NE	0-5	CALM	CALM	CLEAR
7-17-79	1404	J	D	0.5	10.0	10.2	10.5	NE	10-15	NE	0.5	OVERCAST
7-18-79	2259	J	N	-	11.8	8.8	7.9	NE	0-5	CALM	CALM	CLEAR
7-19-79	1806	L	D	2.0	12.0	10.0	9.0	S	0-5	CALM	CALM	CLEAR
7-19-79	2051	L	N	-	11.5	11.0	10.5	CALM	CALM	CALM	CALM	CLEAR
7-16-79	1450	M	D	2.0	22.5	22.0	22.0	W	15-20	CALM	CALM	CLEAR
7-16-79	2230	M	N	-	22.5	22.2	22.0	WNW	15-20	CALM	CALM	CLEAR
7-19-79	1726	N	D	2.0	11.0	7.2	6.3	SW	0-5	CALM	CALM	CLEAR
7-19-79	2100	N	N	-	11.0	9.2	5.0	CALM	CALM	CALM	CALM	CLEAR
7-19-79	1648	O	D	2.5	12.0	6.3	6.0	SW	0-5	CALM	CALM	CLEAR
7-19-79	2139	O	N	-	10.0	6.0	4.0	CALM	CALM	CALM	CALM	CLEAR
7-17-79	1136	P	D	BOTTOM	13.0	13.0	13.0	NE	10-15	NE	0.3-0.6	OVERCAST

Appendix 4. Continued.

STARTING DATE	STARTING TIME	STATION	DIEL PERIOD	SECCHI DISC (M)	TEMPERATURE C SURFACE	MID DEPTH	BOTTOM	WIND DIR. FROM	SPEED (MPH)	WAVES DIR. FROM	HT. (M)	WEATHER
7-17-79	2233	P	N	-	11.0	11.0	11.0	NW	0-5	NW	0.6-1.0	CLEAR
7-17-79	1231	Q	D	BOTTOM	11.0	11.0	11.0	NE	10-15	NE	0.3-0.6	OVERCAST
7-17-79	2312	Q	N	-	10.3	10.3	10.3	NW	0-5	NW	0.6-1.0	CLEAR
7-17-79	0330	R	D	BOTTOM	14.5	14.5	14.5	NE	10-15	NE	0.3-0.6	OVERCAST
7-17-79	2344	R	N	-	13.5	13.5	13.5	NW	0-5	NW	0.6-1.0	CLEAR
7-16-79	1521	S	D	BOTTOM	22.3	22.3	22.3	WNW	15-20	WNW	0.1	CLEAR
7-19-79	2130	S	N	-	13.0	13.0	13.0	CALM	CALM	CALM	CALM	CLEAR
7-16-79	1513	V	D	BOTTOM	23.7	23.7	23.7	WNW	15-20	WNW	0.1	CLEAR
7-19-79	2145	V	N	-	18.0	18.0	18.0	CALM	CALM	CALM	CALM	CLEAR
7-19-79	1610	W	D	2.5	11.5	4.5	4.5	CALM	CALM	CALM	CALM	CLEAR
7-19-79	2216	W	N	-	10.2	4.5	4.0	CALM	CALM	CALM	CALM	CLEAR
7-16-79	1501	X	D	2.0	23.4	23.4	23.4	W	15-20	CALM	CALM	CLEAR
7-16-79	2253	X	N	-	23.4	22.5	22.0	WNW	15-20	CALM	CALM	CLEAR
7-15-79	1535	Z	D	1.5	22.0	22.0	22.0	W	15-20	CALM	CALM	CLEAR
7-16-79	2210	Z	N	-	22.1	22.1	22.1	WNW	15-20	CALM	CALM	CLEAR
8-01-79	1447	A	D	1.5	14.5	14.0	14.0	NE	5-10	NE	0-0.3	OVERCAST
8-01-79	2220	A	N	-	15.2	14.5	14.3	NNE	5-10	NW	0.3	OVERCAST
8-01-79	1420	B	D	2.0	14.5	13.0	12.0	NE	5-10	NE	0-0.3	OVERCAST
8-01-79	2156	B	N	-	15.0	14.3	13.5	NNE	5-10	NW	0.3	OVERCAST
8-01-79	1803	C	D	2.5	14.3	13.0	10.0	NE	0-5	NE	0-0.3	OVERCAST
8-01-79	2024	C	N	-	14.0	10.4	9.9	NE	5-10	NW	0-0.3	OVERCAST
8-01-79	1726	D	D	3.0	14.1	9.0	8.0	NE	5-10	NW	0.3	OVERCAST
8-01-79	2052	D	N	-	12.9	9.0	8.0	NE	5-10	NNE	0-0.3	OVERCAST
8-01-79	1649	E	D	3.0	14.9	12.2	6.2	N	5-10	NW	0.3	RAIN
8-01-79	2130	E	N	-	13.3	11.5	9.2	NE	5-10	NW	0-0.1	OVERCAST
8-01-79	1610	F	D	3.3	14.4	10.8	5.8	NW	5-10	NW	0.3	RAIN
8-01-79	2210	F	N	-	13.8	7.7	4.6	S	5-10	NW	0-0.3	OVERCAST
8-01-79	1426	I	D	1.5	14.3	13.7	13.4	ENE	5-10	NE	0-0.3	OVERCAST
8-01-79	2241	I	N	-	16.3	15.3	14.5	ENE	5-10	NW	0-0.3	PT CLOUDY
8-01-79	1416	J	D	2.0	14.0	14.0	12.5	ENE	5-10	NE	0-0.3	OVERCAST
8-01-79	2216	J	N	-	16.3	15.1	14.0	ENE	5-10	NW	0-0.3	PT CLOUDY
8-02-79	1718	L	D	0.5	16.0	11.3	11.2	WSW	5-10	WSW	0.5	HAZE
8-02-79	2035	L	N	-	16.8	11.4	11.2	S	5-10	SSW	0.3	CLEAR
8-02-79	1750	M	D	-	16.5	14.4	13.9	SW	5-10	SW	0-0.3	CLEAR
8-02-79	0020	M	N	-	17.0	15.5	15.0	NE	5-10	CALM	CALM	PT CLOUDY
8-02-79	1641	N	D	2.3	15.2	10.3	10.0	WSW	0-5	SW	0.5	HAZE
8-02-79	2044	N	N	-	15.5	10.0	8.5	SSW	5-10	SW	0.3	HAZE
8-02-79	1604	O	D	2.5	15.0	6.8	6.3	NW	5-10	SW	0.3	HAZE
8-02-79	2119	O	N	-	15.3	13.6	6.2	S	5-10	S	0-0.3	CLEAR
8-01-79	1510	P	D	BOTTOM	14.5	13.0	13.0	NW	0-5	NW	0-0.3	RAIN
8-02-79	2230	P	N	-	15.2	15.2	15.2	NW	5-10	ENE	0.3	OVERCAST
8-01-79	1521	Q	D	BOTTOM	14.2	14.2	14.0	NW	0-5	NW	0-0.3	RAIN
8-01-79	2350	Q	N	-	14.7	14.7	14.7	ENE	5-10	NW	0.3	PT CLOUDY
8-01-79	1458	R	D	BOTTOM	15.8	15.8	14.8	NW	0-5	NW	0-0.3	RAIN
8-02-79	0105	R	N	-	16.5	16.1	15.5	ENE	5-10	NW	0.3	PT CLOUDY

Appendix 4. Continued.

STARTING DATE	STARTING TIME	STATION	DIEL PERIOD	SECCHI DISC (M)	TEMPERATURE C SURFACE	MID DEPTH	BOTTOM	WIND DIR. FROM	SPEED (MPH)	WAVES DIR. FROM	HT. (M)	WEATHER
8-02-79	1800	S	D	BOTTOM	17.5	17.5	17.5	SW	5-10	SW	0.3	CLEAR
8-02-79	0059	S	N	-	17.5	17.5	17.5	NE	5-10	CALM	CALM	PT CLOUDY
8-02-79	1720	V	D	BOTTOM	23.6	23.6	23.4	SW	5-10	SW	0.3	CLEAR
8-02-79	0048	V	N	-	19.5	19.5	19.5	NE	5-10	CALM	CALM	PT CLOUDY
8-02-79	1540	W	D	3.0	15.0	7.0	5.5	SW	5-10	SW	0.5	HAZE
8-02-79	2157	W	N	-	16.0	12.5	7.5	SE	5-10	SW	0-0.3	CLEAR
8-02-79	1744	X	D	-	22.6	16.8	15.0	SW	5-10	SW	0.3	CLEAR
8-01-79	2345	X	N	-	19.5	19.5	19.0	NE	5-10	CALM	CALM	PT CLOUDY
8-02-79	1715	Z	D	-	17.6	15.5	15.5	SW	5-10	SW	0.3	CLEAR
8-01-79	2330	Z	N	-	17.0	16.0	16.0	NE	5-10	CALM	CALM	PT CLOUDY
8-21-79	1719	A	D	BOTTOM	16.3	16.0	15.8	SE	5-10	SW	0-0.3	PT CLOUDY
8-21-79	0058	A	N	-	15.5	15.5	15.2	E	0-5	SE	0-0.3	HAZE
8-21-79	1700	B	D	BOTTOM	16.0	15.5	15.5	SE	5-10	SW	0-0.3	PT CLOUDY
8-22-79	0049	B	N	-	15.5	15.5	15.2	E	0-5	SE	0-0.3	HAZE
8-20-79	1750	C	D	4.0	14.0	13.5	13.5	E	5-10	CALM	CALM	CLEAR
8-20-79	2018	C	N	-	14.0	14.0	14.0	CALM	0-5	CALM	CALM	CLEAR
8-20-79	1715	D	D	5.0	14.5	14.0	14.0	E	5-10	CALM	CALM	CLEAR
8-20-79	2026	D	N	-	14.5	14.0	14.0	CALM	0-5	CALM	CALM	CLEAR
8-20-79	1637	E	D	4.0	13.5	14.0	14.0	E	5-10	CALM	CALM	HAZE
8-20-79	2104	E	N	-	14.0	14.0	14.0	SE	0-5	CALM	CALM	CLEAR
8-20-79	1557	F	D	4.0	14.5	13.5	13.0	E	10-15	CALM	CALM	PT CLOUDY
8-20-79	2143	F	N	-	14.5	14.0	13.5	SE	0-5	CALM	CALM	CLEAR
8-21-79	1602	I	D	BOTTOM	16.5	16.0	16.0	SE	5-10	SE	0-0.3	CLEAR
8-22-79	0314	I	N	-	15.8	15.5	15.3	SE	0-5	SE	0-0.3	CLEAR
8-21-79	1535	J	D	BOTTOM	16.0	15.5	15.3	SE	5-10	SE	0-0.3	CLEAR
8-22-79	0304	J	N	-	15.7	15.5	15.0	SE	0-5	SE	0-0.3	CLEAR
8-21-79	1743	L	D	1.75	16.0	15.2	15.5	SE	10-15	CALM	0-0.1	CLEAR
8-21-79	2018	L	N	-	16.0	15.0	15.0	CALM	CALM	CALM	CALM	CLEAR
8-23-79	1210	M	D	2.5	16.5	15.8	15.5	SE	10-15	CALM	CALM	OVERCAST
8-24-79	0035	M	N	-	16.5	16.0	16.0	ESE	0-5	CALM	CALM	HAZE
8-21-79	1706	N	D	3.5	15.4	14.9	14.9	SE	10-15	SE	0-0.3	CLEAR
8-21-79	2027	N	N	-	15.1	14.3	14.3	CALM	0-5	CALM	CALM	CLEAR
8-21-79	1627	O	D	4.5	15.4	14.9	14.9	ESE	10-15	ESE	0.3	CLEAR
8-21-79	2104	O	N	-	15.0	14.8	14.5	SE	5-10	SE	0-0.1	CLEAR
8-20-79	1405	P	D	BOTTOM	15.5	15.5	15.0	NE	0-5	SW	0-0.1	OVERCAST
8-21-79	0007	P	N	-	14.8	14.8	15.0	SE	0-5	NW	0-0.1	FOG
8-20-79	1430	Q	D	BOTTOM	15.0	15.0	14.5	NE	0-5	SW	0-0.1	OVERCAST
8-20-79	2255	Q	N	-	15.0	15.0	15.0	SE	0-5	NW	0-0.1	FOG
8-20-79	1455	R	D	BOTTOM	14.5	14.5	14.5	NE	0-5	SW	0-0.1	OVERCAST
8-20-79	2328	R	N	-	16.0	16.0	15.1	SE	0-5	NW	0-0.1	FOG
8-20-79	1605	S	D	BOTTOM	15.5	15.5	15.5	NE	0-5	CALM	CALM	OVERCAST
8-21-79	0030	S	N	-	15.2	15.0	15.0	SE	0-5	CALM	CALM	FOG
8-20-79	1655	V	D	BOTTOM	18.5	18.5	18.5	NE	0-5	CALM	CALM	OVERCAST
8-21-79	0110	V	N	-	17.5	17.5	17.5	SE	0-5	CALM	CALM	FOG
8-21-79	1542	W	D	4.0	15.2	14.5	14.5	ESE	10-15	ESE	0.3	CLEAR

Appendix 4. Continued.

STARTING DATE	STARTING TIME	STATION	DIEL PERIOD	SECCHI DISC (M)	TEMPERATURE C SURFACE	TEMPERATURE C MID DEPTH	TEMPERATURE C BOTTOM	WIND DIR. FROM	WIND SPEED (MPH)	WAVES DIR. FROM	WAVES HT. (M)	WEATHER
8-21-79	2142	W	N	-	15.0	15.0	14.6	SE	5-10	CALM	CALM	CLEAR
8-23-79	1220	X	D	BOTTOM	19.3	19.3	18.3	SE	10-15	CALM	CALM	OVERCAST
8-24-79	0005	X	N	-	16.5	16.0	16.0	ESE	0-5	CALM	CALM	HAZE
8-23-79	1255	Z	D	2.5	17.5	17.5	17.0	SE	10-15	CALM	CALM	OVERCAST
8-22-79	2300	Z	N	-	15.7	15.7	15.7	ESE	0-5	CALM	CALM	HAZE
9-19-79	1452	A	D	1.5	15.0	14.7	14.7	NE	15-20	NE	0.3-0.6	CLEAR
9-19-79	2330	A	N	-	14.0	14.0	14.0	NW	5-10	NW	0-0.6	CLEAR
9-19-79	1440	B	D	2.0	13.3	12.0	12.0	NE	15-20	NE	0.3-0.6	CLEAR
9-19-79	2320	B	N	-	14.7	14.5	14.0	NW	5-10	NW	0-0.6	CLEAR
9-17-79	1642	C	D	4.0	14.4	14.0	13.8	S	5-10	SW	1-2	HAZE
9-17-79	1921	C	N	-	14.8	14.2	14.2	S	5-10	SW	1.0	HAZE
9-17-79	1605	D	D	4.0	14.1	13.1	12.8	S	5-10	SW	1-2	HAZE
9-17-79	1930	D	N	-	14.0	12.0	11.5	S	5-10	SW	1.0	HAZE
9-17-79	1540	E	D	4.0	14.5	12.2	12.0	SE	5-10	SW	1-2	HAZE
9-17-79	2005	E	N	-	13.6	11.4	11.4	S	5-10	SW	1.0	HAZE
9-17-79	1502	F	D	3.5	13.8	11.1	11.1	SE	5-10	SW	1-2	HAZE
9-17-79	2043	F	N	-	14.0	11.0	11.0	S	10-15	SW	0.6	HAZE
9-19-79	1127	I	D	1.5	12.9	12.7	12.7	E	0-5	NW	0-0.1	CLEAR
9-19-79	2323	I	N	-	13.7	13.7	13.7	SE	5-10	VAR	0.3	CLEAR
9-19-79	1111	J	D	1.5	13.5	12.5	12.5	E	0-5	NW	0-0.1	CLEAR
9-19-79	2303	J	N	-	15.0	14.0	13.2	SE	5-10	VAR	0.3	CLEAR
9-19-79	1623	L	D	3.0	12.7	11.7	11.7	WNW	5-10	W	0.5	CLEAR
9-19-79	1922	L	N	-	12.2	13.0	12.8	CALM	CALM	WNW	0.3	CLEAR
9-17-79	1604	M	D	1.8	12.7	11.7	11.3	SW	0-5	W	0-0.1	CLEAR
9-17-79	2232	M	N	-	10.5	10.1	12.5	SW	5-10	SW	0-0.1	CLEAR
9-19-79	1545	N	D	3.5	13.3	13.3	11.7	NW	5-10	W	0.3	CLEAR
9-19-79	1930	N	N	-	13.5	12.8	12.5	CALM	CALM	WNW	0.3	CLEAR
9-19-79	1527	O	D	3.25	13.9	13.1	10.9	NW	5-10	NW	0.3	CLEAR
9-19-79	2007	O	N	-	13.6	13.6	11.5	CALM	CALM	CALM	CALM	CLEAR
9-19-79	1340	P	D	BOTTOM	14.5	14.7	14.7	NE	5-10	NW	0-0.3	CLEAR
9-19-79	1937	P	N	-	14.8	14.8	14.0	NW	0-5	NW	0-0.3	CLEAR
9-19-79	1415	Q	D	BOTTOM	14.8	14.8	14.6	NE	5-10	NW	0-0.3	CLEAR
9-19-79	2000	Q	N	-	16.0	16.0	15.0	NW	0-5	NW	0-0.3	CLEAR
9-19-79	1445	R	D	BOTTOM	14.5	14.5	14.7	NE	5-10	NW	0-0.3	CLEAR
9-19-79	2035	R	N	-	15.5	15.5	15.5	NW	0-5	NW	0-0.3	CLEAR
9-17-79	1530	S	D	BOTTOM	12.5	12.5	12.5	SW	0-5	SW	0-0.1	CLEAR
9-17-79	2125	S	N	-	13.0	13.0	13.0	SW	0-5	SW	0-0.1	CLEAR
9-17-79	1450	V	D	BOTTOM	18.2	18.2	18.2	SW	0-5	SW	0-0.1	CLEAR
9-17-79	2015	V	N	-	15.9	15.9	15.9	SW	0-5	SW	0-0.1	CLEAR
9-19-79	1439	W	D	4.0	13.5	12.4	10.1	W	5-10	NW	0.3	CLEAR
9-19-79	2046	W	N	-	14.2	13.1	10.5	SE	0-5	CALM	CALM	HAZE
9-17-79	1547	X	D	1.5	16.7	14.3	10.8	SW	0-5	W	0-0.1	CLEAR
9-17-79	2221	X	N	-	17.0	13.3	12.5	SW	0-5	SW	0-0.1	CLEAR
9-17-79	1635	Z	D	1.5	12.8	12.5	12.5	SW	0-5	W	0-0.1	CLEAR
9-17-79	2145	Z	N	-	14.2	13.7	13.7	SW	0-5	SW	0-0.1	CLEAR

APPENDIX 5

Appendix 5. Physical and limnological parameters measured at the time sled tows were performed.

STARTING DATE	STARTING TIME	STATION	DIEL PERIOD	SECCHI DISC (M)	TEMPERATURE C SURFACE	MID DEPTH	BOTTOM	WIND DIR. FROM	SPEED (MPH)	WAVES DIR. FROM	HT. (M)	WEATHER
4-17-79	1440	A	D	1.2	8.4	8.4	8.4	NW	10-15	NW	0.5-1.0	CLEAR
4-16-79	2319	A	N	-	7.0	7.0	7.0	NW	5-10	NW	0.5	PT. CLOUDY
4-17-79	1448	B	D	1.2	7.8	7.8	7.8	NW	10-15	NW	0.5-1.0	CLEAR
4-16-79	2347	B	N	-	7.5	7.5	7.5	NW	5-10	NW	0.5	PT. CLOUDY
4-17-79	1459	C	D	2.5	4.6	4.6	4.6	NW	10-15	NW	0.5-1.0	CLEAR
4-17-79	0001	C	N	-	5.0	5.0	4.6	NW	5-10	NW	0.5	PT. CLOUDY
4-17-79	1509	D	D	3.0	2.5	3.0	3.0	NW	10-15	NW	0.5-1.0	CLEAR
4-17-79	0010	D	N	-	3.0	3.0	3.0	NW	5-10	NW	0.5	PT. CLOUDY
4-17-79	1530	E	D	3.5	2.5	2.5	3.0	NW	10-15	NW	0.5-1.0	CLEAR
4-16-79	0023	E	N	-	2.5	2.5	2.5	NW	5-10	NW	0.5	PT. CLOUDY
4-17-79	1540	F	D	3.5	2.5	2.5	2.5	NW	10-15	NW	0.5-1.0	CLEAR
4-17-79	0037	F	N	-	2.5	2.5	3.0	NW	5-10	NW	0.5	PT. CLOUDY
4-17-79	1652	I	D	1.0	7.6	7.6	7.6	NW	10-15	NW	0.5-1.0	CLEAR
4-17-79	0116	I	N	-	7.3	7.3	7.3	NE	5-10	NW	0.3	PT. CLOUDY
4-17-79	1645	J	D	1.0	8.4	8.0	8.0	NW	10-15	NW	0.5-1.0	CLEAR
4-17-79	0129	J	N	-	7.1	7.1	7.0	NE	5-10	NW	0.3	PT. CLOUDY
4-17-79	1635	L	D	2.5	3.5	3.5	3.8	NW	10-15	NW	0.5-1.0	CLEAR
4-17-79	0143	L	N	-	3.9	3.9	3.9	NE	5-10	NW	0.3	PT. CLOUDY
4-17-79	1625	N	D	2.5	2.5	2.5	2.5	NW	10-15	NW	0.5-1.0	CLEAR
4-18-79	2018	N	N	-	2.5	2.5	2.5	NE	5-10	NW	0.3	PT. CLOUDY
4-17-79	1615	O	D	3.0	2.3	2.3	2.3	NW	10-15	NW	0.5-1.0	CLEAR
4-18-79	2007	O	N	-	2.5	2.5	2.5	NE	5-10	NW	0.3	PT. CLOUDY
4-17-79	1431	P	D	1.0	7.4	7.4	7.4	NW	10-15	NW	0.5-1.0	CLEAR
4-16-79	2303	P	N	-	7.4	7.4	7.4	NW	10-15	NW	0.5-1.0	CLEAR
4-17-79	1700	Q	D	1.0	7.6	7.6	7.6	NW	10-15	NW	0.5	CLEAR
4-17-79	0105	Q	N	-	7.1	7.0	7.0	NW	5-10	NW	0.3	PT. CLOUDY
4-17-79	1605	W	D	2.75	2.3	2.3	2.1	NW	10-15	NW	0.5-1.0	CLEAR
4-18-79	1956	W	N	-	2.5	2.0	2.0	NE	5-10	NW	0.3	PT. CLOUDY
5-15-79	1242	A	D	1.5	13.8	13.8	13.8	NW	5-10	NW	0.3-0.6	CLEAR
5-16-79	2220	A	N	-	13.0	13.0	13.0	CALM	0-5	CALM	CALM	CLEAR
5-15-79	1249	B	D	3.5	13.4	13.4	13.4	NW	5-10	NW	0.3-0.6	CLEAR
5-16-79	2228	B	N	-	13.0	12.5	12.0	CALM	0-5	CALM	CALM	CLEAR
5-15-79	1301	C	D	2.5	13.4	13.4	13.4	NW	5-10	NW	0.3-0.6	CLEAR
5-16-79	2236	C	N	-	12.5	12.0	12.0	CALM	0-5	CALM	CALM	CLEAR
5-15-79	1310	D	D	2.3	13.4	12.1	11.9	NW	5-10	NW	0.3-0.6	CLEAR
5-16-79	2245	D	N	-	12.5	12.0	11.0	CALM	0-5	CALM	CALM	CLEAR
5-15-79	1320	E	D	2.5	12.5	11.8	11.0	NW	5-10	NW	0.3-0.6	CLEAR
5-15-79	2255	E	N	-	12.3	12.0	10.0	SE	5-10	CALM	CALM	CLEAR
5-15-79	1331	F	D	3.0	12.5	11.8	11.0	NW	5-10	NW	0.3-0.6	CLEAR
5-16-79	2306	F	N	-	12.3	12.0	10.0	SE	5-10	CALM	CALM	CLEAR
5-15-79	1515	I	D	1.8	15.0	15.0	14.5	NW	10-15	NW	0.5-1.0	CLEAR
5-16-79	0020	I	N	-	12.8	12.8	12.8	SE	5-10	CALM	0-0.3	CLEAR
5-15-79	1505	J	D	2.0	13.4	13.4	12.5	NW	10-15	NW	0.5-1.0	CLEAR
5-16-79	0007	J	N	-	12.8	12.8	12.8	SE	5-10	CALM	0-0.3	CLEAR
5-15-79	1455	L	D	0.9	13.5	13.5	12.4	NW	10-15	NW	0.5-1.0	CLEAR

Appendix 5. Continued.

STARTING DATE	STARTING TIME	STATION	DIEL PERIOD	SECCHI DISC (M)	TEMPERATURE C SURFACE	MID DEPTH	BOTTOM	WIND DIR. FROM	SPEED (MPH)	WAVES DIR. FROM	HT. (M)	WEATHER
5-16-79	2358	L	N	-	12.5	12.0	11.8	SE	5-10	CALM	0-0.3	CLEAR
5-15-79	1440	N	D	1.2	12.0	11.6	11.2	NW	10-15	NW	0.5-1.0	CLEAR
5-16-79	2345	N	N	-	12.0	11.0	11.0	SE	5-10	CALM	0-0.3	CLEAR
5-15-79	1430	O	D	1.5	12.0	12.0	11.8	NW	10-15	NW	0.5-1.0	CLEAR
5-16-79	2335	O	N	-	12.0	12.0	10.0	SE	0-5	CALM	0-0.3	CLEAR
5-15-79	1234	P	D	BOTTOM	13.8	13.8	13.8	NW	5-10	NW	0.3-0.6	CLEAR
5-16-79	2210	P	N	-	13.0	13.0	13.0	CALM	0-5	CALM	CALM	CLEAR
5-15-79	1525	Q	D	BOTTOM	15.2	14.9	14.6	NW	10-15	NW	0.5-1.0	CLEAR
5-16-79	0030	Q	N	-	12.8	12.8	12.8	SE	5-10	CALM	0-0.3	CLEAR
5-15-79	1420	W	D	2.5	12.0	11.7	11.5	NW	10-15	NW	0.5-1.0	CLEAR
5-16-79	2325	W	N	-	12.0	12.0	8.8	SE	0-5	CALM	0-0.3	CLEAR
6-05-79	1217	A	D	1.5	13.5	12.0	12.0	VAR	0-5	NW	0-0.3	PT. CLOUDY
6-04-79	2050	A	N	-	14.0	14.0	14.0	S	0-5	NW	0-0.3	PT. CLOUDY
6-05-79	1454	B	D	2.3	12.5	11.3	11.3	NW	5-10	NW	0.3-0.6	PT. CLOUDY
6-04-79	2117	B	N	-	13.5	13.5	12.5	S	0-5	NW	0-0.3	PT. CLOUDY
6-05-79	1518	C	D	2.5	11.5	11.0	10.5	NW	5-10	NW	0.3-0.6	PT. CLOUDY
6-04-79	2134	C	N	-	13.5	13.5	11.5	S	0-5	NW	0-0.3	PT. CLOUDY
6-05-79	1529	D	D	3.3	11.0	11.3	10.0	NW	5-10	NW	0.3-0.6	PT. CLOUDY
6-04-79	2145	D	N	-	13.0	13.0	10.8	S	0-5	NW	0-0.3	PT. CLOUDY
6-05-79	1539	E	D	2.7	11.5	11.5	10.0	NW	5-10	NW	0.3-0.6	PT. CLOUDY
6-04-79	2151	E	N	-	12.5	10.5	10.5	S	0-5	NW	0-0.3	PT. CLOUDY
6-05-79	1553	F	D	3.5	11.8	11.5	9.8	NW	5-10	NW	0.3-0.6	PT. CLOUDY
6-04-79	2204	F	N	-	12.3	10.5	9.8	S	0-5	NW	0-0.3	PT. CLOUDY
6-05-79	1736	I	D	1.5	14.0	13.5	13.5	NW	0-5	NW	0.3-0.6	PT. CLOUDY
6-04-79	2323	I	N	-	13.5	13.5	13.0	S	0-5	NW	0-0.3	RAIN
6-05-79	1717	J	D	1.8	13.5	13.0	13.0	NW	0-5	NW	0.3-0.6	PT. CLOUDY
6-04-79	2302	J	N	-	13.5	12.8	12.5	S	0-5	NW	0-0.3	RAIN
6-05-79	1707	L	D	2.5	12.0	11.2	11.3	NW	0-5	NW	0.3-0.6	PT. CLOUDY
6-04-79	2253	L	N	-	13.5	13.0	11.5	S	0-5	NW	0-0.3	RAIN
6-05-79	1657	N	D	3.0	11.5	10.8	11.0	NW	0-5	NW	0.3-0.6	PT. CLOUDY
6-04-79	2240	N	N	-	13.0	12.5	11.0	S	0-5	NW	0-0.3	RAIN
6-05-79	1643	O	D	2.5	11.7	10.2	9.8	NW	0-5	NW	0.3-0.6	PT. CLOUDY
6-04-79	2333	O	N	-	13.5	11.5	11.0	S	0-5	NW	0-0.3	RAIN
6-05-79	1205	P	D	1.5	13.5	12.0	12.0	VAR	0-5	NW	0-0.3	PT. CLOUDY
6-04-79	2040	P	N	-	13.5	13.5	13.5	S	0-5	NW	0-0.3	PT. CLOUDY
6-05-79	1807	Q	D	1.5	13.5	13.0	13.0	NW	0-5	NW	0.3-0.6	PT. CLOUDY
6-04-79	0002	Q	N	-	13.0	13.0	13.0	S	0-5	NW	0-0.3	RAIN
6-05-79	1750	R	D	1.5	14.0	13.5	13.5	NW	0-5	NW	0.3-0.6	PT. CLOUDY
6-04-79	2330	R	N	-	13.6	13.6	13.6	S	0-5	NW	0-0.3	RAIN
6-05-79	1632	W	D	2.5	11.5	11.0	10.0	NW	0-5	NW	0.3-0.6	PT. CLOUDY
6-04-79	2221	W	N	-	13.0	10.8	10.0	S	0-5	NW	0-0.3	RAIN
6-19-79	1347	A	D	BOTTOM	11.7	11.7	11.7	SSE	15-20	S	0.6-1.0	CLEAR
6-19-79	0100	A	N	-	13.0	13.0	13.0	SE	0-5	SE	0-0.3	CLEAR
6-19-79	1357	B	D	2.5	12.3	12.3	12.3	SSE	15-20	S	0.6-1.0	CLEAR
6-19-79	0037	B	N	-	13.0	13.0	13.0	SE	0-5	SE	0-0.3	CLEAR

Appendix 5. Continued.

STARTING DATE	STARTING TIME	STATION	DIEL PERIOD	SECCHI DISC (M)	TEMPERATURE C SURFACE	MID DEPTH	BOTTOM	WIND DIR. FROM	SPEED (MPH)	WAVES DIR. FROM	HT. (M)	WEATHER
6-19-79	1430	C	D	5.5	11.8	11.6	11.3	SSE	15-20	S	0.6-1.0	CLEAR
6-20-79	0026	C	N	-	14.5	14.5	14.5	SE	0-5	SE	0-0.3	CLEAR
6-19-79	1440	D	D	5.5	11.7	11.7	9.0	SSE	15-20	S	0.6-1.0	CLEAR
6-20-79	0013	D	N	-	13.0	12.6	11.9	SE	0-5	SE	0-0.3	CLEAR
6-19-79	1448	E	D	5.5	12.0	10.0	7.5	SSE	15-20	S	0.6-1.0	CLEAR
6-19-79	2400	E	N	-	14.0	13.9	11.7	SE	0-5	SE	0-0.3	CLEAR
6-19-79	1458	F	D	5.5	12.0	10.0	7.5	SSE	15-20	S	0.6-1.0	CLEAR
6-19-79	2347	F	N	-	14.4	14.2	11.5	SE	0-5	SE	0-0.3	CLEAR
6-19-79	1616	I	D	0.5	13.0	13.0	13.0	SSE	10-15	SW	0.3-0.6	PT. CLOUDY
6-19-79	2236	I	N	-	13.0	13.0	12.7	SE	0-5	SE	0-0.3	CLEAR
6-19-79	1626	J	D	0.5	13.0	13.0	13.0	SSE	10-15	SW	0.3-0.6	PT. CLOUDY
6-19-79	2212	J	N	-	13.6	13.2	12.7	SE	0-5	SE	0-0.3	CLEAR
6-19-79	1643	L	D	1.75	13.5	13.5	12.5	SSE	10-15	SW	0.3-0.6	PT. CLOUDY
6-19-79	2159	L	N	-	13.7	13.3	12.7	SE	0-5	SE	0-0.3	CLEAR
6-19-79	1652	N	D	2.5	13.0	12.5	12.5	SSE	10-15	SW	0.3-0.6	PT. CLOUDY
6-19-79	2146	N	N	-	14.5	14.3	13.2	SE	0-5	SE	0-0.3	CLEAR
6-19-79	1700	O	D	3.0	13.5	13.5	13.0	SSE	10-15	SW	0.3-0.6	PT. CLOUDY
6-19-79	2133	O	N	-	14.0	13.0	12.5	SE	0-5	SE	0-0.3	CLEAR
6-19-79	1338	P	D	1.5	15.5	15.5	13.5	SSE	15-20	S	0.6-1.0	CLEAR
6-20-79	0113	P	N	-	13.5	13.5	13.5	SE	0-5	SE	0-0.3	CLEAR
6-19-79	1653	Q	D	1.5	14.0	14.0	14.0	SSE	10-15	SW	0.3-0.6	PT. CLOUDY
6-19-79	2322	Q	N	-	13.0	13.0	12.7	SE	0-5	SE	0-0.3	CLEAR
6-19-79	1604	R	D	1.0	14.0	14.0	13.5	SSE	10-15	SW	0.3-0.6	PT. CLOUDY
6-19-79	2252	R	N	-	13.0	13.0	13.0	SE	0-5	SE	0-0.3	CLEAR
6-19-79	1709	W	D	3.0	15.5	15.5	15.0	SSE	10-15	SW	0.3-0.6	PT. CLOUDY
6-19-79	2117	W	N	-	14.6	13.5	13.3	SE	0-5	SE	0-0.3	CLEAR
7-02-79	1535	A	D	1.3	11.1	9.8	9.4	NW	0-5	NW	0.3	CLEAR
7-03-79	0008	A	N	-	9.5	8.0	8.0	SW	0-5	SW	0.1	CLEAR
7-02-79	1515	B	D	2.0	9.9	8.0	7.5	NW	0-5	NW	0.3	CLEAR
7-02-79	2344	B	N	-	9.5	7.5	7.5	SW	0-5	SW	0.1	CLEAR
7-02-79	1501	C	D	2.0	10.0	6.5	6.5	NW	0-5	NW	0.3	CLEAR
7-02-79	2330	C	N	-	8.5	6.5	6.5	SW	0-5	SW	0.1	CLEAR
7-02-79	1447	D	D	2.5	8.5	6.0	6.0	NW	0-5	NW	0.3	CLEAR
7-02-79	2318	D	N	-	8.9	6.5	6.0	SW	0-5	SW	0.1	CLEAR
7-02-79	1436	E	D	2.25	9.5	5.9	5.9	NW	0-5	NW	0.3	CLEAR
7-02-79	2305	E	N	-	9.0	5.7	5.7	SW	0-5	SW	0.1	CLEAR
7-02-79	1421	F	D	2.25	9.9	6.0	5.9	NW	0-5	NW	0-.5	CLEAR
7-02-79	2250	F	N	-	9.0	5.6	5.5	SW	0-5	SW	0.1	CLEAR
7-02-79	1735	I	D	1.5	9.6	7.3	7.3	NW	0-5	NW	0.6-1.0	CLEAR
7-03-79	0220	I	N	-	9.6	8.9	8.5	SW	5-10	SW	0-0.3	PT. CLOUDY
7-02-79	1718	J	D	2.0	9.3	8.0	6.5	NW	0-5	NW	0.6-1.0	CLEAR
7-03-79	0240	J	N	-	9.5	7.2	7.2	SW	5-10	SW	0-0.3	PT. CLOUDY
7-02-79	1705	L	D	2.75	9.2	6.3	6.1	NW	0-5	NW	0.6-1.0	CLEAR
7-03-79	0300	L	N	-	8.7	6.6	6.6	SW	5-10	SW	0-0.3	PT. CLOUDY
7-02-79	1654	N	D	2.5	9.6	6.9	5.9	NW	0-5	NW	0.6-1.0	CLEAR

Appendix 5. Continued.

STARTING DATE	STARTING TIME	STATION	DIEL PERIOD	SECCHI DISC (M)	TEMPERATURE C SURFACE	TEMPERATURE C MID DEPTH	TEMPERATURE C BOTTOM	WIND DIR. FROM	WIND SPEED (MPH)	WAVES DIR. FROM	WAVES HT. (M)	WEATHER
7-03-79	0310	N	N	-	8.9	5.9	5.9	SW	5-10	SW	0-0.3	PT. CLOUDY
7-02-79	1642	O	D	2.75	9.8	5.7	5.6	NW	0-5	NW	0.6-1.0	CLEAR
7-03-79	0327	O	N	-	8.0	5.8	5.8	SW	5-10	SW	0-0.3	PT. CLOUDY
7-02-79	1600	P	D	BOTTOM	11.0	11.0	11.2	NW	0-5	NW	0.3	CLEAR
7-03-79	0100	P	N	-	10.0	10.0	10.0	SW	0-5	SW	0.1	CLEAR
7-02-79	1759	Q	D	BOTTOM	11.0	11.0	11.0	NW	0-5	NW	0.6-1.0	CLEAR
7-03-79	0120	Q	N	-	9.6	9.6	9.6	SW	5-10	SW	0-0.3	PT. CLOUDY
7-02-79	1745	R	D	BOTTOM	11.0	11.0	10.7	NW	0-5	NW	0.6-1.0	CLEAR
7-03-79	0200	R	N	-	10.0	10.0	10.0	SW	5-10	SW	0-0.3	PT. CLOUDY
7-02-79	1628	W	D	3.25	9.0	5.7	5.5	NW	0-5	NW	0.6-1.0	CLEAR
7-03-79	0340	W	N	-	7.5	6.0	5.6	SW	5-10	SW	0-0.3	PT. CLOUDY
7-17-79	1121	A	D	1.5	13.0	13.0	13.0	NE	10-15	NE	0.5	OVERCAST
7-18-79	2132	A	N	-	13.0	9.3	9.4	CALM	0-5	CALM	0-0.1	CLEAR
7-17-79	1055	B	D	2.0	10.1	7.8	7.8	NE	10-15	NE	0.5	OVERCAST
7-18-79	2156	B	N	-	12.0	8.5	7.3	CALM	0-5	CALM	0-0.1	CLEAR
7-17-79	1109	C	D	2.2	9.1	6.3	6.2	NE	10-15	NE	0.5	OVERCAST
7-18-79	2217	C	N	-	8.0	4.0	4.0	CALM	0-5	CALM	0-0.1	CLEAR
7-17-79	1120	D	D	2.0	8.9	6.5	6.1	NE	10-15	NE	0.5	OVERCAST
7-18-79	2229	D	N	-	7.0	4.0	4.0	CALM	0-5	CALM	0-0.1	CLEAR
7-17-79	1133	E	D	2.0	9.1	6.5	5.8	NE	10-15	NE	0.5	OVERCAST
7-18-79	2242	E	N	-	8.0	4.0	4.0	CALM	0-5	CALM	0-0.1	CLEAR
7-17-79	1149	F	D	3.0	12.0	6.5	5.4	NE	10-15	NE	0.5	OVERCAST
7-18-79	2256	F	N	-	6.5	4.0	4.0	CALM	0-5	CALM	0-0.1	CLEAR
7-17-79	1314	I	D	0.5	11.4	11.5	11.5	NE	10-15	NE	0.5	OVERCAST
7-18-79	2343	I	N	-	11.7	9.5	8.9	NE	0-5	CALM	CALM	CLEAR
7-17-79	1608	J	D	1.5	10.0	10.2	10.5	NW	15-20	NW	0.6-1.0	PT. CLOUDY
7-18-79	2259	J	N	-	11.8	8.8	7.9	NE	0-5	CALM	CALM	CLEAR
7-17-79	1558	L	D	1.5	9.5	9.2	8.0	NW	15-20	NW	0.6-1.0	PT. CLOUDY
7-18-79	2242	L	N	-	12.3	9.0	6.5	NE	0-5	CALM	CALM	CLEAR
7-17-79	1547	N	D	2.0	10.3	10.0	8.8	NW	15-20	NW	0.6-1.0	PT. CLOUDY
7-18-79	2224	N	N	-	11.5	7.4	5.5	NE	0-5	CALM	CALM	CLEAR
7-17-79	1536	O	D	2.0	13.2	13.0	10.0	NW	15-20	NW	0.6-1.0	PT. CLOUDY
7-18-79	2206	O	N	-	11.2	5.4	5.4	NE	0-5	CALM	CALM	CLEAR
7-17-79	1205	P	D	BOTTOM	13.0	13.0	13.0	NE	10-15	NE	0.5	OVERCAST
7-18-79	2145	P	N	-	13.0	11.0	10.3	CALM	0-5	CALM	0-0.1	CLEAR
7-17-79	1240	Q	D	BOTTOM	14.0	14.0	12.5	NE	10-15	NE	0.5	OVERCAST
7-18-79	2330	Q	N	-	11.0	10.8	8.7	NE	0-5	CALM	CALM	CLEAR
7-17-79	1328	R	D	BOTTOM	14.5	14.5	14.5	NE	10-15	NE	0.5	OVERCAST
7-18-79	2356	R	N	-	12.3	11.5	11.0	NE	0-5	CALM	CALM	CLEAR
7-17-79	1525	W	D	2.5	13.5	13.0	6.3	NW	15-20	NW	0.6-1.0	PT. CLOUDY
7-18-79	2145	W	N	-	10.5	5.0	4.7	NE	0-5	CALM	CALM	CLEAR
8-01-79	1447	A	D	1.5	14.5	14.0	14.0	NE	5-10	NE	0-0.3	OVERCAST
8-01-79	2220	A	N	-	15.2	14.5	14.3	ENE	5-10	NW	0.3	OVERCAST
8-01-79	1429	B	D	2.0	14.5	13.0	12.0	NE	5-10	NE	0-0.3	OVERCAST
8-01-79	2156	B	N	-	15.0	14.3	13.5	ENE	5-10	NW	0.3	OVERCAST

Appendix 5. Continued.

STARTING DATE	STARTING TIME	STATION	DIEL PERIOD	SECCHI DISC (M)	TEMPERATURE C SURFACE	TEMPERATURE C MID DEPTH	TEMPERATURE C BOTTOM	WIND DIR. FROM	WIND SPEED (MPH)	WAVES DIR. FROM	WAVES HT. (M)	WEATHER
8-01-79	1405	C	D	2.0	15.0	15.0	15.0	NE	5-10	NE	0-0.3	OVERCAST
8-01-79	2145	C	N	-	15.0	14.3	12.4	ENE	5-10	NW	0.3	OVERCAST
8-01-79	1352	D	D	2.5	19.5	16.0	15.5	NE	5-10	NE	0-0.3	OVERCAST
8-01-79	2136	D	N	-	15.0	12.5	11.6	ENE	5-10	NW	0.3	OVERCAST
8-01-79	1340	E	D	3.0	19.5	15.5	12.0	NE	5-10	NE	0-0.3	OVERCAST
8-01-79	2119	E	N	-	15.0	11.2	8.6	ENE	5-10	NW	0.3	OVERCAST
8-01-79	1312	F	D	3.0	19.5	17.0	15.0	NE	5-10	NE	0-0.3	OVERCAST
8-01-79	2112	F	N	-	15.4	9.4	6.9	ENE	5-10	NW	0.3	OVERCAST
8-01-79	1427	I	D	1.5	14.3	13.7	13.4	ENE	5-10	NE	0-0.3	OVERCAST
8-01-79	2241	I	N	-	16.3	15.3	14.5	ENE	5-10	NW	0.3	OVERCAST
8-01-79	1407	J	D	2.0	14.0	14.0	12.5	ENE	5-10	NE	0-0.3	OVERCAST
8-01-79	2216	J	N	-	16.3	15.1	14.0	ENE	5-10	NW	0.3	OVERCAST
8-01-79	1355	L	D	2.0	16.9	16.5	10.9	ENE	5-10	NE	0-0.3	OVERCAST
8-01-79	2204	L	N	-	16.5	15.7	13.5	ENE	5-10	NW	0.3	OVERCAST
8-01-79	1342	N	D	3.0	18.2	15.7	15.3	ENE	5-10	NE	0-0.3	OVERCAST
8-01-79	0045	N	N	-	15.7	12.5	9.2	ENE	5-10	NW	0.3	OVERCAST
8-01-79	1327	O	D	3.5	18.6	16.3	14.2	ENE	5-10	NE	0-0.3	OVERCAST
8-01-79	2142	O	N	-	15.7	11.8	6.8	ENE	5-10	NW	0.3	OVERCAST
8-01-79	1510	P	D	1.5	14.5	13.0	13.0	NE	5-10	NE	0-0.3	OVERCAST
8-01-79	2230	P	N	-	15.2	15.2	15.2	ENE	5-10	NW	0.3	OVERCAST
8-01-79	1515	Q	D	1.0	14.0	13.9	13.9	ENE	5-10	NE	0-0.3	OVERCAST
8-01-79	2337	Q	N	-	14.7	14.7	14.7	ENE	5-10	NW	0.3	OVERCAST
8-01-79	1452	R	D	1.0	15.3	14.9	14.7	ENE	5-10	NE	0-0.3	OVERCAST
8-01-79	2308	R	N	-	16.5	16.1	15.5	ENE	5-10	NW	0.3	OVERCAST
8-01-79	1313	W	D	3.0	19.2	16.1	9.3	ENE	5-10	NE	0-0.3	OVERCAST
8-01-79	2127	W	N	-	16.2	10.8	8.0	ENE	5-10	NW	0-3	OVERCAST
8-21-79	1600	A	D	BOTTOM	16.3	16.0	15.8	SE	10-15	SSE	0-0.3	PT. CLOUDY
8-22-79	0058	A	N	-	15.5	15.5	15.2	ESE	0-5	SSE	0-0.3	HAZE
8-21-79	1541	B	D	BOTTOM	16.0	15.5	15.5	SE	10-15	SSE	0-0.3	PT. CLOUDY
8-22-79	0025	B	N	-	15.5	15.5	15.2	ESE	0-5	SSE	0-0.3	HAZE
8-21-79	1517	C	D	4.0	15.5	15.0	15.0	SE	10-15	SSE	0-0.3	PT. CLOUDY
8-22-79	0011	C	N	-	15.5	15.3	15.0	ESE	0-5	SSE	0-0.3	HAZE
8-21-79	1506	D	D	5.0	15.5	15.3	15.1	SE	10-15	SSE	0-0.3	PT. CLOUDY
8-21-79	2357	D	N	-	15.5	15.5	15.1	ESE	0-5	SSE	0-0.3	HAZE
8-21-79	1452	E	D	4.0	15.5	15.1	14.5	SE	10-15	SSE	0-0.3	PT. CLOUDY
8-21-79	2344	E	N	-	15.7	15.5	15.0	ESE	0-5	SSE	0-0.3	HAZE
8-21-79	1441	F	D	4.0	15.5	15.0	14.5	SE	10-15	SSE	0-0.3	PT. CLOUDY
8-21-79	2329	F	N	-	15.7	15.5	15.5	ESE	0-5	SSE	0-0.3	HAZE
8-21-79	1602	I	D	BOTTOM	16.5	16.0	16.0	SE	5-10	SSE	0-0.3	CLEAR
8-22-79	0314	I	N	-	15.8	15.5	15.3	ESE	0-5	SSE	0-0.3	HAZE
8-21-79	1535	J	D	BOTTOM	16.0	15.5	15.3	SE	5-10	SSE	0-0.3	CLEAR
8-22-79	0251	J	N	-	15.7	15.5	15.0	ESE	0-5	SSE	0-0.3	HAZE
8-21-79	1516	L	D	3.0	16.0	15.5	14.8	SE	5-10	SSE	0-0.3	CLEAR
8-22-79	0238	L	N	-	16.0	15.5	15.2	ESE	0-5	SSE	0-0.3	HAZE
8-21-79	1459	N	D	3.0	16.0	15.6	15.2	SE	5-10	SSE	0-0.3	CLEAR

Appendix 5. Continued.

STARTING DATE	STARTING TIME	STATION	DIEL PERIOD	SECCHI DISC (M)	TEMPERATURE C SURFACE	MID DEPTH	BOTTOM	WIND DIR. FROM	SPEED (MPH)	WAVES DIR. FROM	HT. (M)	WEATHER
8-22-79	0225	N	N	-	16.0	15.5	15.0	ESE	0-5	SSE	0-0.3	HAZE
8-21-79	1445	O	D	5.0	16.0	15.5	14.5	SE	5-10	SSE	0-0.3	CLEAR
8-22-79	0211	O	N	-	16.0	15.3	15.0	ESE	0-5	SSE	0-0.3	HAZE
8-21-79	1630	P	D	BOTTOM	16.0	16.0	16.5	SE	5-10	SSE	0-0.3	CLEAR
8-22-79	0111	P	N	-	15.7	15.5	15.5	ESE	0-5	SSE	0-0.3	HAZE
8-21-79	1632	Q	D	BOTTOM	16.0	16.0	16.0	SE	5-10	SSE	0-0.3	CLEAR
8-22-79	0133	Q	N	-	16.0	16.0	15.2	ESE	0-5	SSE	0-0.3	HAZE
8-21-79	1612	R	D	BOTTOM	16.5	16.0	16.0	SE	5-10	SSE	0-0.3	CLEAR
8-22-79	0325	R	N	-	16.0	16.0	15.5	ESE	0-5	SSE	0-0.3	HAZE
8-21-79	1429	W	D	5.0	15.5	15.5	15.5	SE	5-10	SSE	0-0.3	CLEAR
8-22-79	0157	W	N	-	15.5	15.5	15.5	ESE	0-5	SSE	0-0.3	HAZE
9-19-79	1128	A	D	1.8	13.5	12.7	12.5	NE	15-20	NE	0.3-0.6	CLEAR
9-19-79	2330	A	N	-	14.0	14.0	14.0	NW	5-10	NW	0-0.6	CLEAR
9-19-79	1052	B	D	2.0	13.3	12.0	12.0	NE	15-20	NE	0.3-0.6	CLEAR
9-19-79	2311	B	N	-	14.5	14.0	13.0	NW	5-10	NW	0-0.6	CLEAR
9-19-79	1039	C	D	2.3	13.0	12.0	12.0	NE	15-20	NE	0.3-0.6	CLEAR
9-19-79	2258	C	N	-	14.5	14.0	9.0	NW	5-10	NW	0-0.6	CLEAR
9-19-79	1026	D	D	2.0	13.0	11.7	11.7	NE	15-20	NE	0.3-0.6	CLEAR
9-19-79	2246	D	N	-	14.2	13.8	9.0	NW	5-10	NW	0-0.6	CLEAR
9-19-79	1013	E	D	2.0	13.5	11.5	10.7	NE	15-20	NE	0.3-0.6	CLEAR
9-19-79	2233	E	N	-	14.0	13.8	12.0	NW	5-10	NW	0-0.6	CLEAR
9-19-79	0959	F	D	2.0	13.5	11.5	10.0	NE	15-20	NE	0.3-0.6	CLEAR
9-19-79	2215	F	N	-	14.0	11.5	10.8	NW	5-10	NW	0-0.6	CLEAR
9-19-79	1127	I	D	1.5	12.9	12.7	12.7	ENE	0-5	NW	0.3-0.6	CLEAR
9-19-79	2323	I	N	-	13.7	13.7	13.7	SE	5-10	VAR	0.3	CLEAR
9-19-79	1055	J	D	1.5	13.5	12.5	12.5	ENE	0-5	NW	0.3-0.6	CLEAR
9-19-79	2303	J	N	-	15.0	14.0	13.2	SE	5-10	VAR	0.3	CLEAR
9-19-79	1042	L	D	2.0	12.7	11.7	11.7	ENE	0-5	NW	0.3-0.6	CLEAR
9-19-79	2249	L	N	-	15.2	12.7	11.1	SE	5-10	VAR	0.3	CLEAR
9-19-79	1030	N	D	2.5	12.5	10.9	10.1	ENE	0-5	NW	0.3-0.6	CLEAR
9-19-79	2236	N	N	-	13.3	13.3	11.7	SE	5-10	VAR	0.3	CLEAR
9-19-79	1019	O	D	2.5	12.5	10.7	10.0	ENE	0-5	NW	0.3-0.6	CLEAR
9-19-79	2223	O	N	-	13.9	13.1	10.9	SE	5-10	VAR	0.3	CLEAR
9-19-79	1145	P	D	1.8	14.5	14.3	14.0	NE	15-20	NE	0.3-0.6	CLEAR
9-19-79	2340	P	N	-	14.0	14.0	14.0	NW	5-10	NW	0-0.6	CLEAR
9-19-79	1157	Q	D	.75	13.3	12.7	12.7	ENE	0-5	NW	0.3-0.6	CLEAR
9-19-79	2351	Q	N	-	14.0	14.0	14.0	SE	5-10	VAR	0.3	CLEAR
9-19-79	1143	R	D	.75	14.7	14.5	14.5	ENE	0-5	NW	0.3-0.6	CLEAR
9-19-79	2335	R	N	-	13.7	13.7	13.7	SE	5-10	VAR	0.3	CLEAR
9-19-79	1005	W	D	3.0	12.8	10.7	9.1	ENE	0-5	NW	0.3-0.6	CLEAR
9-19-79	2207	W	N	-	13.5	12.4	10.1	SE	5-10	VAR	0.3	CLEAR

APPENDIX 6

Appendix 6. Monthly length-frequency distributions of species caught during 1979 in the J. H. Campbell Plant study area (Ottawa County, Michigan). Catches from all gear were pooled. Absence of data for either Pigeon Lake or Lake Michigan indicates no fish caught.

ALEWIFE - LAKE MICHIGAN

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
10	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
20	0	0	0	0	0	0	0	0	323	2	2	0	0	1	0	1	0	0	325	4
30	0	0	0	0	0	0	0	0	982	176	87	5	547	142	366	122	0	0	1982	445
40	0	0	0	0	0	0	0	0	635	21	79	23	1441	96	4640	1424	2	0	6797	1564
50	0	0	0	0	0	0	0	0	12	2	50	82	980	24	5487	1830	66	6	6595	1944
60	0	0	0	0	0	0	0	0	0	0	38	144	604	14	2577	696	53	6	3272	860
70	0	0	0	0	0	0	1	0	0	0	40	91	288	1	640	24	28	0	997	116
80	0	0	1	0	1	1	1	6	0	0	8	24	85	2	29	2	2	0	127	35
90	0	0	0	0	0	2	1	1	0	4	0	1	33	0	6	1	0	0	40	9
100	0	0	0	2	0	2	0	5	0	11	0	5	1	0	0	0	1	0	2	25
110	0	0	0	3	3	6	2	6	0	30	1	9	0	0	0	0	0	0	6	54
120	0	0	0	3	5	6	1	5	0	22	1	1	0	0	0	0	0	0	7	37
130	0	0	0	2	3	2	0	2	0	2	0	0	0	0	0	0	0	0	3	8
140	0	0	0	0	2	1	1	0	1	10	0	5	0	0	0	0	0	0	4	16
150	0	0	0	4	3	12	1	1	4	14	10	19	0	0	0	0	0	0	18	50
160	0	0	4	43	48	114	11	99	23	55	25	72	0	0	0	0	0	0	111	383
170	0	0	9	175	150	231	43	224	59	142	107	114	0	0	0	1	0	0	368	887
180	0	0	8	104	184	222	36	102	35	103	60	50	0	0	0	0	0	0	323	581
190	0	0	0	39	45	84	13	50	10	17	8	10	0	0	0	0	0	0	76	200
200	0	0	0	30	15	39	6	30	1	4	9	6	0	0	0	0	0	0	31	109
210	0	0	0	20	4	9	4	15	0	1	4	2	0	0	0	0	0	0	12	47
220	0	0	0	1	1	4	1	7	0	0	0	1	0	0	0	0	0	0	2	13
230	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	3
TOTALS	0	0	22	427	464	735	122	555	2085	618	529	664	3979	280	13745	4101	152	12	21098	7392

ALEWIFE - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
20	0	0	0	0	0	0	0	0	0	11	0	3	0	0	0	0	0	0	0	14
30	0	0	0	0	0	0	0	0	2102	1871	9	62	1	2	0	0	0	0	2112	1935
40	0	0	0	0	0	0	0	0	285	556	4	256	0	1	0	0	0	0	289	813
50	0	0	0	0	0	0	0	0	3	0	0	10	0	0	0	0	0	0	3	10
170	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2
TOTALS	0	0	0	0	0	1	0	1	2390	2438	13	331	1	3	0	0	0	0	2404	2774

Appendix 6. Continued.

BANDED KILLIFISH - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
40	0	0	0	0	1	0	0	0	0	2	0	1	1	0	0	0	0	0	2	3
50	0	0	0	0	2	0	0	0	0	0	0	1	1	0	0	0	0	0	3	1
TOTALS	0	0	0	0	3	0	0	0	0	2	0	2	2	0	0	0	0	0	5	4

BLACK BULLHEAD - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
250	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

BLACK CRAPPIE - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
50	0	0	0	0	0	0	0	0	0	1	0	8	0	0	0	0	0	0	0	9
60	0	0	0	0	0	0	0	0	0	0	0	26	0	0	0	0	0	0	0	26
70	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	1	0	0	0	6
100	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	2
110	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
120	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
130	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	3
160	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	0	1	0	1	0	1	0	45	0	0	0	1	0	0	0	49

BLACKSIDE DARTER - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
50	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
60	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	2

Appendix 6. Continued.

BLUEGILL - PIGEON LAKE

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
20	0	0	0	0	0	0	0	0	6	7	10	23	2	3	0	0	0	0	18	33
30	0	0	0	0	0	0	0	0	4	2	119	312	24	51	0	4	0	0	147	369
40	0	0	0	0	0	0	0	0	0	0	3	0	2	13	0	4	0	0	5	17
50	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
TOTALS	0	0	0	0	0	0	0	0	10	9	132	335	28	69	0	8	0	0	170	421

BLUNTNOSE MINNOW - LAKE MICHIGAN

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
40	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
60	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
TOTALS	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	3

BLUNTNOSE MINNOW - PIGEON LAKE

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
20	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
30	0	0	0	0	0	0	0	0	4	20	5	5	1	0	2	1	0	0	12	26
40	0	1	0	16	0	0	0	0	26	139	22	6	0	2	4	9	0	0	52	173
50	0	0	4	24	0	3	6	6	1	1	46	5	0	0	1	0	0	0	58	39
60	0	2	4	3	0	2	0	7	17	5	8	0	0	0	0	1	0	0	29	20
70	0	1	0	2	0	1	0	1	0	1	2	1	0	2	0	1	0	0	2	10
80	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
TOTALS	0	4	8	45	0	6	6	14	48	167	83	17	2	4	7	12	0	0	154	269

BOWFIN - PIGEON LAKE

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
520	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1
680	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	2

Appendix 6. Continued.

BROOK SILVERSIDE - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
30	0	0	0	0	0	0	0	0	1	0	1	7	2	2	0	0	0	0	4	9
40	0	0	0	0	0	0	0	0	3	0	1	18	3	6	1	1	0	0	8	25
50	0	0	0	0	0	0	0	0	0	0	0	9	0	6	16	3	0	0	16	18
60	0	0	0	0	0	0	0	0	0	0	0	2	0	1	2	0	0	0	2	3
70	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
TOTALS	0	0	0	0	2	0	0	0	4	0	2	36	5	15	19	4	0	0	32	55

BROWN BULLHEAD - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
30	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	3
50	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	3
270	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
280	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
320	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	0	1	0	1	0	5	0	1	0	1	0	0	0	0	0	9

BROWN TROUT - LAKE MICHIGAN

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
120	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
160	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1
170	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
220	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2
230	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2
240	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1
260	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
290	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	3
300	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2
310	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
320	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	3
330	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
340	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
350	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
380	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	2
420	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
430	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
440	1	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4
450	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
460	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
470	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
480	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
490	0	1	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	4
500	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1
510	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1
520	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2
540	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
550	1	3	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	6
560	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
570	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
580	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	2
590	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
600	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
610	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
620	0	0	0	1	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	4
630	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
640	0	0	0	2	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	4
650	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	3
660	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
670	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	3
710	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
TOTALS	8	19	2	14	0	13	3	6	1	3	0	12	1	4	1	1	0	0	16	72

BROWN TROUT - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
120	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Appendix 6. Continued.

CARP - LAKE MICHIGAN

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
580	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
590	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
610	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
640	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
660	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
700	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	2
710	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
740	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
TOTALS	0	2	0	0	0	1	0	0	0	2	1	0	0	2	1	1	0	0	2	8

CHANNEL CATFISH - LAKE MICHIGAN

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
380	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
490	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
520	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
570	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
590	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	2
TOTALS	0	0	0	0	0	0	0	0	1	0	0	3	0	2	0	0	0	1	1	6

CHINOOK SALMON - LAKE MICHIGAN

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
80	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
90	0	0	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	3
100	0	0	1	4	5	5	0	5	0	0	0	0	0	0	0	0	0	0	6	14
110	0	0	0	9	1	4	0	4	0	0	0	0	0	0	0	0	0	0	1	17
150	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
170	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
190	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
200	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2
210	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
220	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
230	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
260	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	1
270	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
280	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
310	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
330	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
370	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2
420	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	2
850	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
940	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2
TOTALS	0	4	3	18	6	10	0	11	0	2	4	6	0	1	0	2	0	0	13	54

Appendix 6. Continued.

CHINOOK SALMON - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
80	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
100	0	0	0	1	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	7
120	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
130	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
340	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
TOTALS	0	0	0	2	0	3	0	6	0	0	0	0	0	1	0	0	0	0	0	12

COHO SALMON - LAKE MICHIGAN

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
90	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
140	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2
150	0	0	1	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	3
160	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
260	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
310	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
330	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
460	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
470	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
570	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
580	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
590	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
610	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
630	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
TOTALS	0	4	1	3	0	0	0	0	0	3	0	4	1	2	0	0	0	0	2	16

COHO SALMON - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
120	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
130	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3

COMMON SHINER - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
90	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2
150	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	4

Appendix 6. Continued.

EMERALD SHINER - LAKE MICHIGAN

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
50	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
70	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0
80	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
90	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1
100	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	2	1	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	4	3

EMERALD SHINER - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
20	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
30	1	2	11	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	9
40	6	4	7	65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	69
50	2	3	0	7	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	11
60	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
70	0	0	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	1
80	0	1	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4
110	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	9	12	23	82	0	0	0	1	0	1	0	0	0	0	0	0	0	0	32	96

FATHEAD MINNOW - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
30	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
40	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
50	0	0	0	0	0	1	1	3	0	0	0	0	0	0	0	0	0	0	1	4
60	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	3	1
70	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0
TOTALS	0	0	2	4	1	1	1	4	0	0	1	0	0	0	1	0	0	0	6	9

Appendix 6. Continued.

GIZZARD SHAD - LAKE MICHIGAN

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
60	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
80	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	2	0
90	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	0	0	4
100	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
110	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1
140	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
150	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
160	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	1	2
170	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
190	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
230	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
270	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
400	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1
410	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	2
420	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1
430	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
450	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
460	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	2
470	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
480	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
500	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
TOTALS	0	3	1	0	0	1	0	1	0	2	0	2	5	16	1	1	2	0	9	26

GIZZARD SHAD - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
40	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
TOTALS	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1

GOLDEN REDHORSE - LAKE MICHIGAN

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
400	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
410	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
530	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
550	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
570	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2
580	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
590	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
600	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	0	2	0	7	0	0	0	0	0	1	0	0	0	0	0	10

Appendix 6. Continued.

GOLDEN SHINER - PIGEON LAKE

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
30	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
40	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
50	0	0	0	9	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	10
70	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
130	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	2
150	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	16	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	20

GOLDFISH - PIGEON LAKE

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
50	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
300	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	2

GRASS PICKEREL - PIGEON LAKE

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
130	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1

GREEN SUNFISH - LAKE MICHIGAN

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
TOTALS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1

Appendix 6. Continued.

JOHNNY DARTER - LAKE MICHIGAN

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
20	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
30	0	0	0	0	0	5	0	0	0	0	0	1	0	0	0	0	0	0	0	6
40	0	0	1	7	2	11	1	7	0	9	0	2	0	0	0	0	0	1	4	37
50	0	0	1	5	0	8	0	3	0	9	2	22	1	11	1	2	1	1	6	61
60	0	4	7	23	4	13	1	11	0	9	1	31	4	27	2	8	2	6	21	132
70	0	2	17	30	4	28	0	13	0	6	0	8	0	7	1	3	0	5	22	102
80	0	1	1	7	1	2	0	1	0	0	0	0	0	0	0	0	0	0	2	11
TOTALS	0	7	27	72	11	67	2	35	0	33	3	65	5	45	4	13	3	13	55	350

JOHNNY DARTER - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
10	0	0	0	0	29	0	0	0	0	0	0	0	0	0	0	0	0	0	29	0
20	0	0	0	0	33	0	2	0	0	0	0	0	0	0	0	0	0	0	35	0
30	0	0	1	0	0	1	4	34	2	9	2	0	0	5	2	1	0	0	11	50
40	1	2	4	13	0	6	8	15	20	10	10	40	1	11	0	6	0	0	44	103
50	2	4	0	10	2	0	7	11	1	8	15	54	3	30	1	13	0	0	31	130
60	0	0	0	6	3	3	3	4	0	1	1	14	0	8	0	0	0	0	7	36
70	1	1	1	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	2	4
80	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
TOTALS	4	7	6	30	67	10	24	64	23	28	28	109	4	56	3	20	0	0	159	324

LAKE STURGEON - LAKE MICHIGAN

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
900	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Appendix 6. Continued.

LAKE TROUT - LAKE MICHIGAN

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
120	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
130	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
140	0	0	2	0	0	3	1	1	0	0	0	0	0	0	0	0	0	0	3	4
150	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	2
160	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
180	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
210	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	3
270	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
460	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0
490	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
510	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
520	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
530	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
540	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
550	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	1
560	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
570	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2
580	0	1	0	1	0	0	1	2	0	0	0	0	0	0	0	1	0	0	1	5
590	0	0	0	2	0	0	0	1	0	0	0	3	0	2	0	0	0	0	0	8
600	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	1	0	0	1	3
610	0	1	0	0	0	0	1	0	0	1	1	1	0	1	0	3	0	0	2	7
620	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	2	1
630	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2
640	0	0	0	3	0	2	0	0	0	1	0	1	0	6	0	1	0	0	0	14
650	0	0	0	1	0	0	0	0	0	1	0	1	0	3	0	1	0	0	0	7
660	0	1	0	0	0	1	0	0	0	0	0	2	0	1	0	0	0	0	0	5
670	0	0	0	0	0	1	0	1	0	2	0	1	1	5	1	1	0	0	2	11
680	0	0	0	1	0	1	0	2	0	0	0	0	3	8	1	3	0	0	4	15
690	0	0	0	0	0	0	0	1	0	1	0	2	0	3	1	0	0	0	1	7
700	0	1	0	0	0	1	0	0	0	2	1	1	0	6	1	1	0	0	2	12
710	0	0	0	0	0	1	0	0	0	1	0	1	1	4	0	1	0	0	1	8
720	0	0	0	0	0	0	0	0	0	0	0	2	0	8	1	0	0	0	1	10
730	0	0	0	0	0	0	1	0	0	0	0	0	0	3	1	2	0	0	2	5
740	0	0	0	0	0	0	0	0	0	0	2	2	0	3	0	0	0	0	2	5
750	0	0	0	0	0	1	0	0	0	1	0	1	0	4	1	1	0	0	1	8
760	0	0	0	0	0	0	0	1	0	0	0	0	0	3	2	0	0	0	2	4
770	0	0	0	0	0	0	0	1	0	1	0	0	1	3	0	1	0	0	1	6
780	0	0	0	0	0	0	1	0	0	0	0	0	1	3	1	1	0	0	3	4
790	0	0	0	0	0	0	0	0	0	0	0	1	3	1	0	0	0	0	3	2
800	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	2
810	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1
820	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
840	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	2
870	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
880	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
890	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
TOTALS	0	9	3	10	0	13	10	12	0	13	5	22	14	73	12	25	1	0	45	177

Appendix 6. Continued.

LAKE WHITEFISH - LAKE MICHIGAN

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
160	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
200	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
240	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2
270	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
290	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
360	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
370	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2
380	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
390	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
400	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	2
490	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
500	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
510	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
520	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
540	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2
550	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
560	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	2
570	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	2
600	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	0	9	0	12	0	1	0	5	0	0	0	0	0	0	0	27

LARGEMOUTH BASS - PIGEON LAKE

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
20	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	3	1
30	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	4
40	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
50	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	1	3
60	0	0	0	0	0	0	0	0	0	1	4	2	0	0	0	0	0	0	4	3
70	0	0	0	0	0	0	0	0	3	3	5	1	0	2	0	1	0	0	8	7
80	0	0	0	0	1	0	0	0	1	0	9	2	0	1	0	0	0	0	11	3
90	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	6	0
100	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	1	2
150	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
250	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	4	1	0	4	5	4	26	11	1	3	0	1	0	0	36	24

LOGPERCH - PIGEON LAKE

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
40	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0
50	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0
TOTALS	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3	0

Appendix 6. Continued.

SPOTTAIL SHINER - LAKE MICHIGAN

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
30	0	0	0	0	0	0	0	0	1	0	4	0	0	1	0	3	0	0	5	4
40	0	0	2	6	0	0	3	2	0	0	20	2	1	6	1	6	0	2	27	24
50	0	0	7	14	9	6	8	12	2	2	3	1	1	3	0	2	15	2	45	42
60	0	0	2	4	5	18	24	15	6	5	3	1	1	3	3	13	31	19	75	78
70	1	0	0	3	6	3	9	4	8	18	6	4	0	13	2	14	8	9	40	68
80	1	5	8	8	27	98	27	1	5	13	1	11	2	24	3	11	23	1	97	172
90	0	2	25	152	160	829	582	10	23	124	2	9	1	20	0	8	13	4	806	1158
100	0	2	51	231	173	673	298	15	88	412	45	85	20	283	4	67	24	10	703	1778
110	3	9	34	197	25	566	165	70	68	167	31	86	7	170	3	45	17	12	353	1322
120	0	5	35	324	119	514	287	94	37	245	14	53	12	112	0	22	4	4	508	1373
130	0	2	22	178	22	176	62	32	9	75	3	29	4	90	0	11	4	4	126	597
140	0	0	4	6	0	12	2	0	0	7	0	3	2	7	0	1	0	0	8	36
150	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	2	1
160	0	0	0	0	0	0	26	0	0	0	0	0	0	0	0	0	0	0	26	0
TOTALS	5	26	190	1123	547	2895	1493	255	247	1068	133	284	51	732	16	203	139	67	2821	6653

SPOTTAIL SHINER - PIGOEN LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
10	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
20	0	0	1	0	0	0	0	0	41	3	402	4	0	0	0	0	0	0	444	7
30	0	4	0	0	0	0	0	0	42	0	1506	10	2	0	8	17	0	0	1558	31
40	0	9	3	6	0	0	0	0	108	11	363	5	1	11	14	14	0	0	489	56
50	0	4	3	4	2	4	0	0	8	17	1	2	0	11	3	7	0	0	17	49
60	0	0	8	30	2	1	0	0	0	0	3	0	0	4	2	2	0	0	15	37
70	0	2	13	37	1	2	0	0	1	3	0	0	0	1	0	2	0	0	15	47
80	0	0	16	77	0	16	1	4	0	0	0	0	0	0	2	2	0	0	19	99
90	0	1	1	70	0	41	1	38	0	1	0	0	0	0	0	0	0	0	2	151
100	0	0	0	50	0	23	0	33	0	0	1	0	0	0	1	0	0	0	2	106
110	0	0	1	28	0	3	0	2	0	0	0	0	0	0	0	0	0	0	1	33
120	0	0	0	10	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	13
130	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
150	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	20	46	312	5	92	2	80	201	35	2276	21	3	27	30	44	0	0	2563	631

TADPOLE MADTOM - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
30	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	2
40	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	3
50	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4
70	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	3
80	0	0	0	0	1	0	0	0	0	1	0	2	0	1	0	0	0	0	1	4
TOTALS	0	0	0	0	1	0	0	0	0	4	0	10	0	2	0	0	0	0	1	16

Appendix 6. Continued.

LONGNOSE SUCKER - LAKE MICHIGAN

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
40	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
60	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3	0
90	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
160	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
230	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
270	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
290	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
350	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
370	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	1
390	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
400	0	0	0	0	0	1	0	2	0	0	0	1	0	0	0	0	0	0	0	4
410	0	0	0	2	0	1	1	1	0	0	0	1	0	0	0	0	0	0	1	5
420	0	0	0	2	0	2	3	1	0	0	1	0	0	0	0	1	0	0	4	6
430	0	0	0	5	0	1	1	1	0	0	2	3	0	0	0	0	0	0	3	10
440	0	0	0	0	0	1	4	5	0	1	1	1	0	2	0	0	0	0	5	10
450	0	0	0	6	0	0	2	3	0	1	0	4	0	1	0	0	0	0	2	15
460	0	0	1	6	0	1	0	11	0	0	0	3	0	1	0	0	0	0	1	22
470	0	0	0	4	0	1	2	12	0	0	0	3	0	1	0	0	0	0	2	21
480	0	0	0	4	0	0	0	12	1	0	0	0	0	0	0	0	0	0	1	16
490	0	0	2	4	0	1	2	2	0	0	1	0	0	0	0	1	0	0	5	8
500	0	0	1	2	0	1	2	2	0	0	0	0	0	1	0	0	0	0	3	6
510	0	0	1	3	0	0	0	4	0	0	1	1	0	0	0	1	0	0	2	9
520	0	0	0	2	0	0	0	4	0	0	1	0	0	0	0	0	0	0	1	6
530	0	0	0	2	0	0	2	4	0	0	0	3	0	2	0	0	0	0	2	11
540	0	0	0	0	0	0	0	3	0	0	0	0	0	1	0	0	0	0	0	4
550	0	0	0	0	0	0	1	1	0	0	0	0	0	2	0	0	0	0	1	3
560	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
580	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
590	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
620	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	5	43	0	14	24	73	1	3	9	21	0	12	0	3	0	0	39	169

LONGNOSE SUCKER - PIGEON LAKE

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
40	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
50	0	0	0	0	0	0	5	1	0	0	0	0	0	0	0	0	0	0	5	1
60	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0	2	3
70	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	0	0	7	6	0	0	0	0	0	0	0	0	0	0	7	6

MOTTLED SCULPIN - LAKE MICHIGAN

LENGTH INTERVAL	APP DAY	APP NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
TOTALS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1

Appendix 6. Continued.

MOTTLED SCULPIN - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
20	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3
40	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	2
50	0	0	0	0	0	0	0	0	0	0	3	7	0	2	0	0	0	0	3	9
60	0	0	0	0	0	0	0	0	0	0	0	11	0	1	0	1	0	0	0	13
70	0	0	0	0	0	0	0	0	0	0	1	2	0	19	0	2	0	0	1	23
80	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	3	0	0	0	15
90	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	3
TOTALS	0	0	0	0	0	0	0	3	0	1	4	21	0	36	0	7	0	0	4	68

NINESPINE STICKLEBACK - LAKE MICHIGAN

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
30	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
40	0	0	0	0	1	2	0	3	0	0	0	0	0	1	0	1	0	0	1	7
50	0	0	0	0	2	11	0	8	0	0	0	0	0	0	1	1	0	0	3	20
60	0	1	4	16	8	32	4	45	0	0	0	0	0	0	0	0	1	0	17	94
70	0	1	16	19	12	72	12	91	0	0	0	0	0	0	0	0	0	0	40	183
80	0	0	0	0	0	3	0	4	0	0	0	0	0	0	0	0	0	0	0	7
TOTALS	0	2	20	35	23	120	16	151	0	1	0	0	0	1	1	2	1	0	61	312

NINESPINE STICKLEBACK - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
30	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
40	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3
50	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
70	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	1	3	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	4	5

NORTHERN PIKE - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
80	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
90	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
100	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
160	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
260	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
280	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
400	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
530	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
560	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
660	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
680	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
TOTALS	3	0	0	1	0	3	0	0	0	0	0	3	0	1	0	0	0	0	3	8

Appendix 6. Continued.

PUMPKINSEED - PIGEON LAKE

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
80	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
100	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
110	0	0	0	0	1	0	2	0	0	0	3	0	0	0	0	0	0	0	6	0
120	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	3	1
130	0	0	0	0	1	0	2	0	0	1	1	0	0	0	0	0	0	0	4	1
140	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	3
150	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	2
190	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	3	1	5	1	1	2	6	4	0	0	0	0	0	0	15	8

RAINBOW SMELT - LAKE MICHIGAN

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
20	0	0	0	0	0	0	0	0	0	0	4	0	0	1	0	0	0	0	4	1
30	0	0	0	0	0	0	1	0	5062	847	26	62	4	3	0	3	0	0	5093	915
40	1	11	16	15	3	0	0	0	7989	2774	1189	838	56	101	51	60	2	0	9307	3799
50	6	41	93	121	18	13	16	12	141	63	778	525	125	148	248	279	74	28	1499	1230
60	13	102	217	339	31	40	80	111	5	3	95	19	30	47	127	219	176	161	774	1041
70	13	79	198	889	21	25	313	217	14	5	29	2	3	1	18	26	171	131	780	1375
80	4	18	197	636	15	22	364	125	18	6	27	16	4	8	3	0	31	30	663	861
90	2	3	77	299	11	5	333	49	17	7	30	17	7	4	0	0	1	0	478	384
100	0	0	14	65	0	0	159	20	22	16	39	9	8	1	2	0	0	0	244	111
110	0	0	17	30	0	0	69	3	29	25	32	15	25	1	0	1	1	0	173	75
120	0	0	11	29	0	2	56	5	14	52	39	17	4	2	0	0	3	0	127	107
130	0	0	7	16	0	0	44	4	13	18	24	32	2	2	0	0	3	0	93	72
140	0	0	11	28	0	1	50	12	18	21	12	36	1	0	0	0	0	0	92	98
150	0	2	1	14	1	2	18	22	16	53	32	41	3	2	0	0	1	1	72	137
160	0	1	0	8	0	1	8	8	12	19	50	70	0	0	0	0	1	0	71	107
170	0	5	1	7	0	0	7	1	5	12	41	54	0	1	0	0	0	0	54	80
180	0	2	1	3	0	0	1	0	2	2	24	16	0	1	0	0	2	0	30	24
190	0	2	2	3	0	0	0	0	1	5	9	16	1	0	0	0	1	0	14	26
200	0	0	0	0	0	0	0	0	0	0	3	2	1	1	0	0	1	0	5	3
210	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	1	2
220	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2
230	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	1
240	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
TOTALS	39	266	863	2504	100	111	1519	589	13378	3928	2486	1789	274	325	449	588	468	352	19576	10452

RAINBOW SMELT - PIGEON LAKE

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
30	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
50	0	0	0	1	0	0	0	0	0	0	0	0	1	3	0	0	0	0	1	4
60	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	2
70	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	1	3	0	0	0	0	5	0	0	0	1	5	0	0	0	0	7	8

Appendix 6. Continued.

RAINBOW TROUT - LAKE MICHIGAN

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
140	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
180	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
190	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
410	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
510	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
540	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
570	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
580	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
600	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
610	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
640	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
650	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
660	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	3
670	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	2
680	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
690	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2
700	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
710	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
740	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	2	15	0	1	0	0	0	0	0	0	0	0	2	3	1	5	0	0	5	24

ROCK BASS - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
30	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0	0	0	1	3
40	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	0	0	0	1	3
50	0	0	0	0	0	0	0	0	0	0	0	1	0	5	0	0	0	0	0	6
80	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	2
90	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
100	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	3
110	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	4
120	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	3
130	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
140	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	3
150	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
160	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	0	0	0	0	3
170	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	0	0	0	7	1	7	1	12	0	9	0	0	0	0	2	35

Appendix 6. Continued.

ROUND WHITEFISH - LAKE MICHIGAN

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
160	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
180	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
230	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	2	1
240	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
250	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1
260	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
270	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
280	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
290	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
300	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2
310	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	2
320	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	2	2
330	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	1	0	0	1	3
340	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	0	1	3
380	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
400	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
410	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
420	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	2
430	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	2
450	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
460	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	2
470	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	2
TOTALS	0	2	0	4	1	3	0	0	0	2	1	5	7	12	0	6	1	0	10	34

SAND SHINER - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
30	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
40	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1
60	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0
70	0	0	2	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0
80	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
TOTALS	2	1	5	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	16	1

SHORTHEAD REDHORSE - LAKE MICHIGAN

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
470	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
490	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
510	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
700	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	0	2	0	0	0	0	0	1	0	1	0	0	0	0	0	4

Appendix 6. Continued.

SILVER REDHORSE - LAKE MICHIGAN

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
510	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
570	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0
TOTALS	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	3	0

SLIMY SCULPIN - LAKE MICHIGAN

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
20	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
30	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
40	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
50	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
60	2	2	3	12	0	0	0	1	0	0	0	0	0	0	0	0	0	0	5	15
70	0	8	1	18	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	27
80	1	22	3	11	0	0	0	0	0	0	0	0	0	1	1	0	0	4	5	38
90	1	19	3	10	0	1	0	0	0	0	0	0	0	0	0	0	1	11	5	41
100	0	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	7	1	12
110	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	4	57	11	54	0	2	0	1	0	1	0	0	0	1	1	0	1	23	17	139

SMALLMOUTH BASS - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
70	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
90	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
140	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
180	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
220	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
290	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
TOTALS	0	0	0	0	2	0	0	1	0	1	0	2	0	0	0	0	0	0	2	4

Appendix 6. Continued.

TROUT-PERCH - LAKE MICHIGAN

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
20	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
30	0	0	2	13	0	4	0	0	0	0	0	0	1	0	0	0	0	0	3	17
40	0	0	12	48	0	34	2	46	1	2	0	0	0	2	0	0	0	0	15	132
50	0	0	1	19	0	17	36	128	8	26	0	2	0	0	0	0	0	0	45	192
60	0	0	2	1	0	4	10	41	15	55	2	22	4	9	0	0	0	0	33	132
70	0	0	1	9	0	1	5	7	11	19	9	28	3	15	0	2	0	0	29	81
80	0	0	7	70	0	7	1	6	2	7	2	11	0	9	0	2	1	0	13	112
90	0	0	8	54	2	9	4	40	2	12	1	4	0	3	0	0	0	0	17	122
100	0	1	2	24	1	12	26	40	6	32	2	20	1	10	0	1	1	0	39	140
110	0	2	1	66	1	26	22	58	2	41	5	39	1	41	0	12	0	1	32	286
120	0	1	10	51	0	14	4	23	4	17	0	18	0	21	2	29	0	0	20	174
130	0	0	4	18	0	5	3	9	0	8	1	3	0	8	0	8	2	0	10	59
140	0	0	0	12	0	0	0	2	0	3	0	1	0	5	0	10	1	0	1	33
150	0	0	0	2	0	0	0	1	0	1	0	1	0	2	0	2	1	0	1	9
160	0	0	0	2	0	0	0	0	0	0	0	0	0	1	0	4	0	0	0	7
TOTALS	0	4	50	390	4	133	113	401	51	223	22	149	10	126	2	70	6	1	258	1497

TROUT-PERCH - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
40	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	3
50	0	0	0	0	0	0	0	1	0	0	0	2	0	1	0	0	0	0	0	4
60	0	0	0	0	0	0	0	0	0	0	0	4	0	13	0	0	0	0	0	17
70	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0	0	0	0	0	5
80	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
TOTALS	0	0	0	0	0	0	0	1	0	0	0	7	0	22	0	0	0	0	0	30

Appendix 6. Continued.

UNIDENTIFIED COREGONINAE — LAKE MICHIGAN

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
50	0	0	1	0	0	0	0	0	0	0	1	0	1	1	32	28	0	0	35	29
60	0	0	1	1	0	0	1	0	0	0	13	11	12	17	42	77	0	0	69	106
70	0	0	0	0	0	2	1	5	0	0	63	88	85	85	105	217	1	2	255	399
80	0	0	0	0	1	6	3	10	0	0	50	83	55	99	161	476	1	2	271	676
90	0	0	3	2	10	60	47	31	0	2	3	19	19	16	60	216	1	0	143	346
100	0	0	0	0	15	120	94	220	20	8	0	3	0	1	0	14	2	0	131	366
110	0	0	0	0	0	54	231	398	48	35	3	12	0	0	0	0	0	0	282	499
120	0	0	0	0	0	11	304	426	33	72	1	21	0	0	0	0	0	0	338	530
130	0	0	0	0	1	3	122	209	42	86	1	12	0	0	0	0	0	0	166	310
140	0	0	0	0	0	2	14	47	8	34	2	13	0	0	0	0	0	0	24	96
150	0	0	0	0	0	0	18	36	0	2	1	16	0	1	0	0	0	0	19	55
160	0	0	0	0	0	2	17	111	0	3	0	3	0	0	0	0	0	0	17	119
170	0	0	0	0	0	7	35	120	0	3	2	1	0	0	0	0	0	0	37	131
180	0	0	0	0	0	10	38	91	0	3	0	1	0	0	0	0	0	0	38	105
190	0	0	0	0	0	4	12	51	0	4	3	0	0	0	0	0	0	0	15	59
200	0	0	0	0	0	0	6	20	0	1	2	0	0	0	0	0	0	0	8	21
210	0	0	0	0	0	1	2	4	0	0	0	0	0	0	0	0	0	0	2	5
220	0	0	0	0	0	0	0	4	0	1	0	0	0	0	0	0	0	0	0	5
230	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	1
240	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
280	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	5	3	27	282	945	1785	151	254	146	283	172	220	401	1030	5	4	1852	3861

UNIDENTIFIED COREGONINAE — PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
40	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
50	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
60	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
70	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
TOTALS	0	0	0	0	4	0	0	0	0	0	0	0	1	0	0	0	0	0	5	0

Appendix 6. Continued.

WHITE SUCKER - LAKE MICHIGAN

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
290	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
300	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	1
310	0	0	0	0	0	1	0	1	0	0	0	2	0	0	0	0	0	0	0	4
320	0	0	0	0	0	2	0	0	0	2	1	0	0	0	0	0	0	0	1	4
330	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	3
340	0	0	1	0	0	0	0	1	0	0	0	4	0	0	0	2	0	0	1	7
350	0	0	0	0	0	0	0	0	1	0	0	6	0	0	0	0	0	0	1	6
360	0	0	0	1	0	2	1	2	0	0	0	6	0	0	0	0	0	0	1	11
370	0	0	0	0	0	1	1	1	0	1	1	6	0	0	0	0	0	0	2	9
380	0	0	0	0	0	1	2	6	2	2	2	6	0	1	0	0	0	0	6	16
390	0	0	1	1	0	3	0	3	0	2	0	3	0	0	0	0	0	0	1	12
400	0	0	0	2	0	0	1	2	1	3	1	6	0	0	0	0	0	0	3	13
410	0	0	1	0	0	6	0	2	3	4	2	4	0	0	0	0	0	0	6	16
420	0	0	0	1	0	1	0	6	2	0	3	6	0	0	0	0	0	0	5	14
430	0	0	1	2	0	4	2	3	2	2	2	10	0	1	0	0	0	0	7	22
440	0	0	1	4	0	3	0	6	2	4	2	10	0	1	0	0	0	0	5	28
450	0	0	0	2	0	2	1	5	0	1	1	5	0	0	0	1	0	0	2	16
460	0	0	1	4	0	3	10	4	0	3	6	8	0	1	0	1	0	0	17	24
470	0	0	1	4	0	2	5	2	0	2	0	10	0	0	0	0	0	0	6	20
480	0	0	0	2	0	3	1	4	0	0	1	7	0	0	0	0	0	0	2	16
490	0	0	2	0	0	2	2	4	0	1	0	4	0	2	0	0	0	0	4	13
500	0	0	0	2	0	1	0	1	0	1	4	6	0	0	0	0	0	0	4	11
510	0	0	0	2	0	1	1	5	0	0	0	3	0	0	0	0	0	0	1	11
520	0	0	1	2	0	1	0	4	0	1	2	0	0	1	0	0	0	0	3	9
530	0	0	0	0	0	2	1	4	0	0	3	3	0	0	0	0	0	0	4	9
540	0	0	0	1	0	0	0	1	0	0	1	3	0	0	0	0	0	0	1	5
550	0	0	0	2	0	0	2	3	0	0	0	2	0	0	0	0	0	0	2	7
560	0	0	1	1	0	0	1	3	0	0	1	0	0	0	0	0	0	0	3	4
570	0	0	0	1	0	0	0	4	0	0	0	1	0	0	0	0	0	0	0	6
580	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	3
590	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
600	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1
TOTALS	0	0	12	35	0	42	31	82	13	29	34	124	0	7	0	4	0	0	90	323

WHITE SUCKER - PIGEON LAKE

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
40	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
50	0	0	0	0	0	0	2	5	0	0	0	0	0	0	0	0	0	0	2	5
60	0	0	0	0	0	0	1	5	0	0	0	0	0	0	0	0	0	0	1	5
70	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
90	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2
120	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
170	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
320	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
380	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	1	0	2	3	14	0	0	0	2	0	0	0	0	0	0	3	19

Appendix 6. Continued.

YELLOW BULLHEAD - PIGEON LAKE

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
250	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1

YELLOW PERCH - LAKE MICHIGAN

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
30	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
50	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	2	0	3	2
60	0	1	0	0	0	1	0	1	0	0	0	0	0	1	0	0	1	0	1	4
70	0	1	0	2	0	0	2	3	0	0	0	0	0	1	1	0	39	5	42	12
80	0	1	0	1	0	4	3	8	0	0	0	0	0	0	0	0	98	18	101	32
90	0	0	0	1	1	5	8	14	0	0	0	0	0	0	0	0	11	3	20	23
100	0	0	0	1	1	0	14	12	3	4	1	3	0	0	0	2	1	0	20	22
110	0	0	0	1	0	0	2	1	7	5	3	3	0	0	0	0	1	0	13	10
120	0	1	0	0	0	1	2	1	3	3	6	3	0	0	0	0	3	0	14	9
130	0	0	0	0	0	0	0	0	0	2	2	2	0	3	0	1	1	0	3	8
140	0	0	0	0	0	2	0	0	1	1	1	2	0	1	0	4	2	0	4	10
150	0	2	1	0	0	1	2	0	6	3	3	4	0	1	0	2	1	1	13	14
160	0	1	0	1	0	9	8	0	8	6	2	9	0	1	0	1	0	1	18	29
170	0	2	0	0	0	3	6	2	7	8	2	5	1	0	0	4	0	0	16	24
180	0	0	0	2	0	0	1	0	3	3	5	6	0	0	0	4	1	0	10	15
190	0	0	0	0	0	0	3	0	2	4	0	5	0	0	0	6	1	0	6	15
200	0	1	0	0	0	1	1	1	2	0	5	2	0	0	0	6	1	0	9	11
210	0	0	0	0	0	0	0	2	6	6	0	2	0	1	0	3	0	0	6	14
220	0	1	0	0	0	0	2	0	2	2	1	5	0	0	0	3	1	0	6	11
230	0	0	0	0	1	1	0	0	0	3	0	0	0	1	0	2	1	1	2	8
240	0	0	0	1	0	1	0	2	1	0	0	2	0	0	0	0	1	0	2	6
250	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	1	0	2	2
260	0	1	0	0	0	1	0	1	0	0	1	0	0	0	0	0	1	0	2	3
270	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
280	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	2	0
290	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
320	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
340	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
370	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	12	1	12	3	33	54	49	53	50	32	55	1	10	2	38	171	29	317	288

APPENDIX 7

Appendix 7. Monthly length-frequency distributions of major species caught in Lake Michigan and Pigeon Lake during 1979 in the vicinity of the J. H. Campbell Plant (Ottawa County, Michigan). Distributions were segregated by gear type.

ALEWIFE

LAKE MICHIGAN - SEINES

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
10	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
20	0	0	0	0	0	0	0	0	322	2	0	0	0	0	0	0	0	0	322	2
30	0	0	0	0	0	0	0	0	981	175	70	1	0	121	0	2	0	0	1051	299
40	0	0	0	0	0	0	0	0	635	21	77	1	0	77	1	2	0	0	713	101
50	0	0	0	0	0	0	0	0	12	2	4	1	0	12	0	0	0	0	16	15
60	0	0	0	0	0	0	0	0	0	0	1	1	0	8	0	0	0	0	1	9
70	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	3
80	0	0	0	0	0	0	0	6	0	0	0	0	0	1	0	0	0	0	0	7
90	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
100	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3
110	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
120	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	1
130	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
160	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	1	2
170	0	0	0	0	0	0	0	10	0	1	0	1	0	0	0	0	0	0	0	12
180	0	0	0	0	0	1	0	12	0	0	0	0	0	0	0	0	0	0	0	13
190	0	0	0	0	0	0	0	4	0	1	0	1	0	0	0	0	0	0	0	6
200	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	0	1	3	43	1950	205	152	8	0	220	1	4	0	0	2106	481

LAKE MICHIGAN - TRAWLS

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
20	0	0	0	0	0	0	0	0	1	0	2	0	0	1	0	1	0	0	3	2
30	0	0	0	0	0	0	0	0	1	1	17	4	547	21	366	120	0	0	931	146
40	0	0	0	0	0	0	0	0	0	0	2	22	1441	19	4639	1422	2	0	6084	1463
50	0	0	0	0	0	0	0	0	0	0	46	81	980	12	5487	1830	66	6	6579	1929
60	0	0	0	0	0	0	0	0	0	0	37	143	604	6	2577	696	53	6	3271	851
70	0	0	0	0	0	0	1	0	0	0	40	89	288	0	640	24	28	0	997	113
80	0	0	1	0	1	1	1	0	0	0	8	24	85	0	29	2	2	0	127	27
90	0	0	0	0	0	2	0	0	0	0	0	0	33	0	6	1	0	0	39	3
100	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	1	0	1	3
110	0	0	0	0	3	1	1	0	0	0	0	0	0	0	0	0	0	0	4	1
120	0	0	0	0	3	2	0	0	0	1	0	0	0	0	0	0	0	0	3	3
130	0	0	0	1	3	2	0	0	0	0	0	0	0	0	0	0	0	0	3	3
140	0	0	0	0	2	1	0	0	0	4	0	0	0	0	0	0	0	0	2	5
150	0	0	0	1	3	10	0	0	0	4	4	0	0	0	0	0	0	0	7	15
160	0	0	0	2	9	58	0	0	0	13	3	0	0	0	0	0	0	0	12	73
170	0	0	2	4	21	70	1	0	0	47	46	4	0	0	0	1	0	0	70	126
180	0	0	1	4	18	56	1	0	1	49	23	1	0	0	0	0	0	0	44	110
190	0	0	0	6	9	34	1	0	0	6	5	0	0	0	0	0	0	0	15	46
200	0	0	0	0	2	11	0	0	0	2	0	0	0	0	0	0	0	0	2	13
210	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
TOTALS	0	0	4	19	75	250	6	0	3	127	233	368	3978	59	13744	4097	152	12	18195	4932

Appendix 7. Continued.

ALEWIFE

LAKE MICHIGAN - BOTTOM GILL NETS

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
80	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
100	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1
110	0	0	0	3	0	3	1	2	0	1	1	5	0	0	0	0	0	0	2	14
120	0	0	0	2	2	1	0	0	0	0	0	1	0	0	0	0	0	0	2	4
130	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
140	0	0	0	0	0	0	1	0	1	2	0	0	0	0	0	0	0	0	2	2
150	0	0	0	0	0	1	0	0	4	6	6	8	0	0	0	0	0	0	10	15
160	0	0	4	10	39	30	7	7	20	26	22	19	0	0	0	0	0	0	92	92
170	0	0	7	22	119	47	35	12	52	46	60	38	0	0	0	0	0	0	273	165
180	0	0	7	21	157	38	29	7	32	34	37	16	0	0	0	0	0	0	262	116
190	0	0	0	5	33	9	11	2	9	10	3	6	0	0	0	0	0	0	56	32
200	0	0	0	3	13	11	6	0	1	2	9	3	0	0	0	0	0	0	29	19
210	0	0	0	1	3	3	4	4	0	1	4	2	0	0	0	0	0	0	11	11
220	0	0	0	1	1	0	1	2	0	0	0	1	0	0	0	0	0	0	2	4
230	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2
TOTALS	0	0	18	69	367	143	95	37	119	129	142	100	1	1	0	0	0	0	742	479

LAKE MICHIGAN - SURFACE GILL NETS

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
90	0	0	0	0	0	0	0	0	0	4	0	1	0	0	0	0	0	0	0	5
100	0	0	0	1	0	0	0	2	0	11	0	4	0	0	0	0	0	0	0	18
110	0	0	0	0	0	2	0	2	0	29	0	4	0	0	0	0	0	0	0	37
120	0	0	0	1	0	3	0	4	0	21	1	0	0	0	0	0	0	0	1	29
130	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2
140	0	0	0	0	0	0	0	0	0	4	0	5	0	0	0	0	0	0	0	9
150	0	0	0	3	0	1	1	1	0	4	0	11	0	0	0	0	0	0	1	20
160	0	0	0	31	0	26	3	91	3	15	0	53	0	0	0	0	0	0	6	216
170	0	0	0	149	10	114	7	202	7	48	1	71	0	0	0	0	0	0	25	584
180	0	0	0	79	9	127	6	83	2	20	0	33	0	0	0	0	0	0	17	342
190	0	0	0	28	3	41	1	44	1	0	0	3	0	0	0	0	0	0	5	116
200	0	0	0	27	0	17	0	29	0	0	0	3	0	0	0	0	0	0	0	76
210	0	0	0	19	0	6	0	11	0	0	0	0	0	0	0	0	0	0	0	36
220	0	0	0	0	0	4	0	5	0	0	0	0	0	0	0	0	0	0	0	9
230	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	339	22	341	18	475	13	157	2	188	0	0	0	0	0	0	55	1500

Appendix 7. Continued.

RAINBOW SMELT

LAKE MICHIGAN - SEINES

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
30	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
40	0	0	0	0	0	0	0	0	1	1	0	4	0	1	0	0	0	0	1	6
50	0	0	0	9	0	0	0	2	0	0	0	0	0	5	1	0	0	0	1	16
60	0	2	0	101	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	130
70	0	1	0	549	0	0	0	101	1	0	0	0	0	0	0	0	0	0	1	651
80	0	1	0	397	0	0	0	28	0	1	0	0	0	0	0	0	0	0	0	427
90	0	0	0	207	0	0	0	11	0	1	0	0	0	0	0	0	0	0	0	219
100	0	0	0	39	0	0	0	8	0	8	0	0	0	0	0	0	0	0	0	55
110	0	0	0	7	0	0	0	0	0	9	0	2	0	0	0	0	0	0	0	18
120	0	0	0	2	0	0	0	1	0	18	0	6	0	0	0	0	0	0	0	27
130	0	0	0	0	0	0	0	0	0	10	0	21	0	0	0	0	0	0	0	31
140	0	0	0	1	0	0	0	0	0	6	0	16	0	0	0	0	0	0	0	23
150	0	0	0	2	0	0	0	0	0	6	0	9	0	0	0	0	0	0	0	17
160	0	0	0	1	0	0	0	0	0	1	0	14	0	0	0	0	0	0	0	16
170	0	0	0	3	0	0	0	0	0	2	0	6	0	0	0	0	0	0	0	11
180	0	0	0	1	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	4
190	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3
TOTALS	0	4	0	1321	0	0	0	178	3	63	0	82	0	6	1	0	0	0	4	1654

LAKE MICHIGAN - TRAWLS

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
20	0	0	0	0	0	0	0	0	0	0	4	0	0	1	0	0	0	0	4	1
30	0	0	0	0	0	0	1	0	5061	847	26	62	4	3	0	3	0	0	5092	915
40	1	11	16	15	3	0	0	0	7988	2773	1189	834	56	100	51	60	2	0	9306	3793
50	6	41	93	112	18	13	16	10	141	63	778	525	125	143	247	279	74	28	1498	1214
60	13	100	217	238	31	40	80	84	5	3	95	19	30	47	127	219	176	161	774	911
70	13	78	198	340	21	25	313	116	13	5	29	2	3	1	18	26	171	131	779	724
80	4	17	197	239	15	22	364	97	18	5	27	16	4	8	3	0	31	30	663	434
90	2	3	77	92	11	5	333	38	17	6	29	17	7	4	0	0	1	0	477	165
100	0	0	14	25	0	0	159	12	22	7	39	9	8	1	2	0	0	0	244	54
110	0	0	17	23	0	0	69	2	29	16	32	13	25	1	0	1	1	0	173	56
120	0	0	11	27	0	0	56	4	13	34	38	8	4	2	0	0	3	0	125	75
130	0	0	7	14	0	0	44	3	11	8	23	6	2	2	0	0	3	0	90	33
140	0	0	10	12	0	0	50	3	10	5	6	11	1	0	0	0	0	0	77	31
150	0	1	1	1	0	0	18	1	4	8	11	2	3	0	0	0	1	1	38	14
160	0	0	0	0	0	0	8	2	2	2	7	0	0	0	0	0	1	0	18	4
170	0	1	0	1	0	0	7	0	0	2	2	1	0	0	0	0	0	0	9	5
180	0	2	1	0	0	0	1	0	0	0	3	0	0	0	0	0	2	0	7	2
190	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	3	1
200	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	2	1
220	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
230	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
240	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
TOTALS	39	254	860	1141	99	105	1519	372	13334	3785	2338	1525	274	314	448	588	468	352	19379	8436

Appendix 7. Continued.

RAINBOW SMELT

LAKE MICHIGAN - BOTTOM GILL NETS

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
90	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
100	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2
120	0	0	0	0	0	1	0	0	1	0	1	3	0	0	0	0	0	0	2	4
130	0	0	0	2	0	0	0	0	2	0	1	3	0	0	0	0	0	0	3	5
140	0	0	1	12	0	1	0	0	8	8	6	7	0	0	0	0	0	0	15	28
150	0	1	0	6	1	2	0	0	12	23	21	21	0	1	0	0	0	0	34	54
160	0	1	0	6	0	0	0	0	10	9	43	39	0	0	0	0	0	0	53	55
170	0	4	1	3	0	0	0	0	5	5	39	32	0	1	0	0	0	0	45	45
180	0	0	0	2	0	0	0	0	2	2	21	10	0	1	0	0	0	0	23	15
190	0	2	1	1	0	0	0	0	1	2	9	11	0	0	0	0	0	0	11	16
200	0	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	3	1
210	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1
220	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
230	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0
TOTALS	0	8	3	33	1	4	0	0	41	50	148	128	0	4	0	0	0	0	193	227

LAKE MICHIGAN - SURFACE GILL NETS

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
110	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
120	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
130	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	3
140	0	0	0	3	0	0	0	9	0	2	0	2	0	0	0	0	0	0	0	16
150	0	0	0	5	0	0	0	21	0	16	0	9	0	1	0	0	0	0	0	52
160	0	0	0	1	0	1	0	6	0	7	0	17	0	0	0	0	0	0	0	32
170	0	0	0	0	0	0	0	1	0	3	0	15	0	0	0	0	0	0	0	19
180	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	3
190	0	0	0	0	0	0	0	0	0	2	0	4	0	0	0	0	0	0	0	6
200	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
210	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
TOTALS	0	0	0	9	0	2	0	39	0	30	0	54	0	1	0	0	0	0	0	135

Appendix 7. Continued.

SPOTTAIL SHINER

LAKE MICHIGAN - SEINES

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
30	0	0	0	0	0	0	0	0	1	0	4	0	0	1	0	0	0	0	5	1
40	0	0	0	0	0	0	3	1	0	0	19	1	0	2	0	1	0	0	22	5
50	0	0	0	1	1	0	6	5	2	2	3	0	0	1	0	1	0	0	12	10
60	0	0	0	0	0	0	15	1	6	5	3	0	0	0	0	1	0	0	24	7
70	1	0	0	1	1	0	4	0	5	16	6	1	0	1	0	0	0	0	17	19
80	1	5	0	1	15	1	27	1	1	11	1	8	0	0	0	0	0	0	45	27
90	0	1	0	35	104	2	580	3	0	31	2	6	0	0	0	0	0	0	686	78
100	0	2	0	56	106	9	290	3	0	94	25	20	0	1	0	1	0	0	421	186
110	0	2	0	28	9	9	25	1	0	25	7	3	0	0	0	0	0	0	41	68
120	0	0	0	43	87	2	15	3	0	9	0	1	0	0	0	0	0	0	102	58
130	0	1	0	6	16	2	8	0	0	1	0	1	0	0	0	0	0	0	24	11
160	0	0	0	0	0	0	26	0	0	0	0	0	0	0	0	0	0	0	26	0
TOTALS	2	11	0	171	339	25	999	18	15	194	70	41	0	6	0	4	0	0	1425	470

LAKE MICHIGAN - TRAWLS

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	3
40	0	0	2	6	0	0	0	1	0	0	1	1	1	4	1	5	0	2	5	19
50	0	0	7	13	8	6	2	7	0	0	0	1	1	2	0	1	15	2	33	32
60	0	0	2	4	5	18	9	14	0	0	0	1	1	3	3	12	31	19	51	71
70	0	0	0	2	5	3	5	4	3	2	0	3	0	12	2	14	8	9	23	49
80	0	0	8	7	12	97	0	0	4	2	0	3	2	24	3	11	23	1	52	145
90	0	1	25	117	55	819	1	6	22	89	0	3	1	19	0	8	13	4	117	1066
100	0	0	47	165	67	579	1	3	76	266	1	29	18	236	3	43	24	10	237	1331
110	0	0	18	95	16	324	1	4	24	71	0	19	7	82	2	24	17	12	85	631
120	0	0	7	125	32	231	0	6	7	87	0	7	11	58	0	3	4	4	61	521
130	0	0	9	80	5	101	0	3	4	44	0	8	3	65	0	2	4	4	25	307
140	0	0	4	1	0	12	0	0	0	2	0	0	2	5	0	0	0	0	6	20
150	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
TOTALS	0	1	129	615	206	2190	19	48	140	563	2	75	47	510	14	126	139	67	696	4195

Appendix 7. Continued.

SPOTTAIL SHINER

LAKE MICHIGAN - BOTTOM GILL NETS

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
90	0	0	0	0	1	8	1	1	1	4	0	0	0	1	0	0	0	0	3	14
100	0	0	4	10	0	85	7	9	12	52	19	36	2	46	1	23	0	0	45	261
110	3	7	16	74	0	231	139	65	44	70	24	59	0	88	1	21	0	0	227	615
120	0	5	28	156	0	280	272	85	29	149	14	39	1	54	0	19	0	0	344	787
130	0	1	13	91	1	73	54	29	5	30	3	19	1	25	0	9	0	0	77	277
140	0	0	0	5	0	0	2	0	0	5	0	3	0	2	0	1	0	0	2	16
150	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1
TOTALS	3	14	61	336	2	677	475	189	91	310	61	156	4	216	2	73	0	0	699	1971

LAKE MICHIGAN - SURFACE GILL NETS

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
110	0	0	0	0	0	2	0	0	0	1	0	5	0	0	0	0	0	0	0	8
120	0	0	0	0	0	1	0	0	1	0	0	6	0	0	0	0	0	0	1	7
130	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2
TOTALS	0	0	0	1	0	3	0	0	1	1	0	12	0	0	0	0	0	0	1	17

Appendix 7. Continued.

YELLOW PERCH

LAKE MICHIGAN - SEINES

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
60	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
70	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2
100	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
TOTALS	0	1	0	0	1	0	0	0	0	0	0	0	0	2	0	0	0	0	1	3

LAKE MICHIGAN - TRAWLS

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
50	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	2	0	3	2
60	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	1	3
70	0	0	0	2	0	0	2	3	0	0	0	0	0	0	1	0	39	5	42	10
80	0	1	0	1	0	4	3	8	0	0	0	0	0	0	0	0	98	18	101	32
90	0	0	0	1	1	4	8	14	0	0	0	0	0	0	0	0	11	3	20	22
100	0	0	0	1	0	0	10	10	2	3	0	0	0	0	0	0	1	0	13	14
110	0	0	0	1	0	0	1	1	6	3	0	0	0	0	0	0	1	0	8	5
120	0	1	0	0	0	0	1	1	2	0	0	0	0	0	0	0	3	0	6	2
130	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	1	0	1	4
140	0	0	0	0	0	2	0	0	1	1	0	0	0	1	0	0	2	0	3	4
150	0	1	0	0	0	0	1	0	5	2	0	1	0	0	0	0	1	1	7	5
160	0	1	0	1	0	1	0	0	3	3	0	1	0	0	0	0	0	1	3	8
170	0	0	0	0	0	0	1	1	6	2	0	0	0	0	0	0	0	0	7	3
180	0	0	0	1	0	0	0	0	3	1	0	0	0	0	0	0	1	0	4	2
190	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	1	3
200	0	0	0	0	0	1	0	1	2	0	0	1	0	0	0	0	1	0	3	3
210	0	0	0	0	0	0	0	1	2	5	0	0	0	0	0	1	0	0	2	7
220	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	1	0	3	2
230	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	1	1	1	1	5
240	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	1	0	2	2
250	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1
260	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1	2
280	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
290	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
320	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
340	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
TOTALS	0	6	0	8	1	17	27	44	35	29	0	4	0	3	2	2	171	29	236	142

Appendix 7. Continued.

YELLOW PERCH

LAKE MICHIGAN - BOTTOM GILL NETS

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
30	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
90	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
100	0	0	0	0	0	0	4	2	1	1	1	2	0	0	0	2	0	0	6	7
110	0	0	0	0	0	0	1	0	1	2	3	3	0	0	0	0	0	0	5	5
120	0	0	0	0	0	1	1	0	1	3	6	3	0	0	0	0	0	0	8	7
130	0	0	0	0	0	0	0	0	0	0	2	2	0	1	0	1	0	0	2	4
140	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	4	0	0	1	6
150	0	1	1	0	0	1	1	0	1	1	3	3	0	1	0	2	0	0	6	9
160	0	0	0	0	0	8	8	0	5	3	2	7	0	1	0	1	0	0	15	20
170	0	2	0	0	0	3	5	1	1	6	2	5	1	0	0	4	0	0	9	21
180	0	0	0	1	0	0	1	0	0	2	5	4	0	0	0	4	0	0	6	11
190	0	0	0	0	0	0	3	0	2	1	0	5	0	0	0	6	0	0	5	12
200	0	1	0	0	0	0	1	0	0	0	5	1	0	0	0	6	0	0	6	8
210	0	0	0	0	0	0	0	1	4	1	0	1	0	1	0	2	0	0	4	6
220	0	1	0	0	0	0	2	0	0	0	1	5	0	0	0	3	0	0	3	9
230	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0	1	0	0	1	3
240	0	0	0	1	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	4
250	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	1
260	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	1
270	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
280	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
370	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	5	1	4	1	16	27	5	18	21	32	46	1	5	0	36	0	0	80	138

LAKE MICHIGAN - SURFACE GILL NETS

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
100	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
160	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
180	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2
210	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5

Appendix 7. Continued.

UNIDENTIFIED COREGONINAE

LAKE MICHIGAN - SEINES

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
60	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	0
70	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
80	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0
90	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
100	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
TOTALS	0	0	0	0	4	0	0	0	0	0	6	0	0	0	0	0	0	0	10	0

LAKE MICHIGAN - TRAWLS

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1
50	0	0	1	0	0	0	0	0	0	0	1	0	1	1	32	28	0	0	35	29
60	0	0	1	1	0	0	1	0	0	0	9	11	12	17	42	77	0	0	65	106
70	0	0	0	0	0	2	1	5	0	0	62	88	85	85	105	217	1	2	254	399
80	0	0	0	0	0	6	3	10	0	0	49	83	55	99	161	476	1	2	269	676
90	0	0	3	2	9	60	47	30	0	2	3	19	19	16	60	216	1	0	142	345
100	0	0	0	0	13	120	94	219	20	8	0	3	0	1	0	14	2	0	129	365
110	0	0	0	0	0	54	222	391	48	35	3	12	0	0	0	0	0	0	273	492
120	0	0	0	0	0	10	272	397	33	71	1	21	0	0	0	0	0	0	306	499
130	0	0	0	0	0	1	106	185	42	85	1	12	0	0	0	0	0	0	149	283
140	0	0	0	0	0	1	10	46	8	34	2	11	0	0	0	0	0	0	20	92
150	0	0	0	0	0	0	17	36	0	2	0	16	0	1	0	0	0	0	17	55
160	0	0	0	0	0	0	15	110	0	3	0	3	0	0	0	0	0	0	15	116
170	0	0	0	0	0	1	33	111	0	3	0	0	0	0	0	0	0	0	33	115
180	0	0	0	0	0	0	35	83	0	3	0	0	0	0	0	0	0	0	35	86
190	0	0	0	0	0	0	8	37	0	4	0	0	0	0	0	0	0	0	8	41
200	0	0	0	0	0	0	4	8	0	1	0	0	0	0	0	0	0	0	4	9
210	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
220	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	3
280	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	5	3	22	255	868	1672	151	252	131	279	172	220	401	1029	5	4	1755	3714

Appendix 7. Continued.

UNIDENTIFIED COREGONINAE

LAKE MICHIGAN - BOTTOM GILL NETS

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
90	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
100	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
110	0	0	0	0	0	0	9	6	0	0	0	0	0	0	0	0	0	0	9	6
120	0	0	0	0	0	1	32	25	0	1	0	0	0	0	0	0	0	0	32	27
130	0	0	0	0	1	2	16	22	0	1	0	0	0	0	0	0	0	0	17	25
140	0	0	0	0	0	1	4	1	0	0	0	2	0	0	0	0	0	0	4	4
150	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	2	0
160	0	0	0	0	0	2	2	1	0	0	0	0	0	0	0	0	0	0	2	3
170	0	0	0	0	0	6	2	9	0	0	2	1	0	0	0	0	0	0	4	16
180	0	0	0	0	0	10	3	8	0	0	0	1	0	0	0	0	0	0	3	19
190	0	0	0	0	0	4	4	14	0	0	3	0	0	0	0	0	0	0	7	18
200	0	0	0	0	0	0	2	12	0	0	2	0	0	0	0	0	0	0	4	12
210	0	0	0	0	0	1	2	3	0	0	0	0	0	0	0	0	0	0	2	4
220	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
230	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	1
240	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
TOTALS	0	0	0	0	1	27	77	106	0	2	9	4	0	0	0	1	0	0	87	140

LAKE MICHIGAN - SURFACE GILL NETS

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
110	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
120	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	4
130	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
TOTALS	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	7

Appendix 7. Continued.

TROUT-PERCH

LAKE MICHIGAN - SEINES

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
70	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2
80	0	0	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18
90	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
100	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3
110	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
120	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
130	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
140	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
160	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
TOTALS	0	3	0	44	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	49

LAKE MICHIGAN - TRAWLS

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
20	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
30	0	0	2	13	0	4	0	0	0	0	0	0	1	0	0	0	0	0	3	17
40	0	0	12	48	0	34	2	46	1	2	0	0	0	2	0	0	0	0	15	132
50	0	0	1	19	0	17	36	128	8	26	0	2	0	0	0	0	0	0	45	192
60	0	0	2	1	0	4	10	41	15	55	2	22	4	9	0	0	0	0	33	132
70	0	0	1	8	0	1	5	7	11	19	9	28	3	14	0	2	0	0	29	79
80	0	0	7	52	0	7	1	6	2	7	2	11	0	9	0	2	1	0	13	94
90	0	0	8	39	2	9	4	40	2	12	1	4	0	3	0	0	0	0	17	107
100	0	0	2	23	1	12	26	39	6	32	2	17	1	10	0	1	1	0	39	134
110	0	0	1	60	0	21	22	53	2	41	5	31	1	38	0	4	0	1	31	249
120	0	0	10	44	0	10	4	22	4	17	0	14	0	15	2	7	0	0	20	129
130	0	0	4	16	0	4	3	9	0	8	1	1	0	8	0	4	2	0	10	50
140	0	0	0	10	0	0	0	2	0	3	0	1	0	5	0	9	1	0	1	30
150	0	0	0	2	0	0	0	1	0	1	0	1	0	2	0	2	1	0	1	9
TOTALS	0	0	50	336	3	123	113	394	51	223	22	132	10	115	2	31	6	1	257	1355

Appendix 7. Continued.

TROUT-PERCH

LAKE MICHIGAN - BOTTOM GILL NETS

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
100	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	2
110	0	0	0	4	1	5	0	5	0	0	0	5	0	3	0	8	0	0	1	30
120	0	1	0	5	0	4	0	1	0	0	0	4	0	6	0	22	0	0	0	43
130	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	4	0	0	0	7
140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
160	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0	0	0	5
TOTALS	0	1	0	10	1	10	0	7	0	0	0	11	0	10	0	39	0	0	1	88

LAKE MICHIGAN - SURFACE GILL NETS

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
100	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
110	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	3
130	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	5

Appendix 7. Continued.

JOHNNY DARTER

LAKE MICHIGAN - TRAWLS

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
20	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
30	0	0	0	0	0	5	0	0	0	0	0	1	0	0	0	0	0	0	0	6
40	0	0	1	7	2	11	1	7	0	9	0	2	0	0	0	0	0	1	4	37
50	0	0	1	5	0	8	0	3	0	9	2	22	1	11	1	2	1	1	6	61
60	0	4	7	23	4	13	1	11	0	9	1	31	4	27	2	8	2	6	21	132
70	0	2	17	30	4	28	0	13	0	6	0	8	0	7	1	3	0	5	22	102
80	0	1	1	7	1	2	0	1	0	0	0	0	0	0	0	0	0	0	2	11
TOTALS	0	7	27	72	11	67	2	35	0	33	3	65	5	45	4	13	3	13	55	350

WHITE SUCKER

LAKE MICHIGAN - SEINES

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
420	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1

LAKE MICHIGAN - TRAWLS

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
380	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
400	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
450	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
470	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	0	0	0	0	1	1	0	2	0	0	0	0	0	0	1	3

Appendix 7. Continued.

WHITE SUCKER

LAKE MICHIGAN - BOTTOM GILL NETS

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
290	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
300	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	1
310	0	0	0	0	0	1	0	1	0	0	0	2	0	0	0	0	0	0	0	4
320	0	0	0	0	0	2	0	0	0	2	1	0	0	0	0	0	0	0	1	4
330	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	3
340	0	0	1	0	0	0	0	1	0	0	0	4	0	0	0	2	0	0	1	7
350	0	0	0	0	0	0	0	0	1	0	0	6	0	0	0	0	0	0	1	6
360	0	0	0	1	0	2	1	2	0	0	0	6	0	0	0	0	0	0	1	11
370	0	0	0	0	0	1	1	1	0	1	1	6	0	0	0	0	0	0	2	9
380	0	0	0	0	0	1	2	6	2	2	2	6	0	1	0	0	0	0	6	16
390	0	0	1	1	0	3	0	3	0	2	0	3	0	0	0	0	0	0	1	12
400	0	0	0	2	0	0	1	2	1	3	1	6	0	0	0	0	0	0	3	13
410	0	0	1	0	0	6	0	2	3	4	2	4	0	0	0	0	0	0	6	16
420	0	0	0	1	0	1	0	6	2	0	3	6	0	0	0	0	0	0	5	14
430	0	0	1	2	0	4	2	3	2	2	2	10	0	1	0	0	0	0	7	22
440	0	0	1	4	0	3	0	6	2	4	2	10	0	1	0	0	0	0	5	28
450	0	0	0	2	0	2	1	5	0	1	1	5	0	0	0	1	0	0	2	16
460	0	0	1	4	0	3	10	4	0	3	6	8	0	1	0	1	0	0	17	24
470	0	0	1	4	0	2	5	2	0	2	0	10	0	0	0	0	0	0	6	20
480	0	0	0	2	0	3	1	4	0	0	1	7	0	0	0	0	0	0	2	16
490	0	0	2	0	0	2	2	4	0	1	0	4	0	2	0	0	0	0	4	13
500	0	0	0	2	0	1	0	1	0	1	4	6	0	0	0	0	0	0	4	11
510	0	0	0	2	0	1	1	5	0	0	0	3	0	0	0	0	0	0	1	11
520	0	0	1	2	0	1	0	4	0	1	2	0	0	1	0	0	0	0	3	9
530	0	0	0	0	0	2	1	4	0	0	3	3	0	0	0	0	0	0	4	9
540	0	0	0	1	0	0	0	1	0	0	1	3	0	0	0	0	0	0	1	5
550	0	0	0	2	0	0	2	3	0	0	0	2	0	0	0	0	0	0	2	7
560	0	0	1	1	0	0	1	3	0	0	1	0	0	0	0	0	0	0	3	4
570	0	0	0	1	0	0	0	4	0	0	0	1	0	0	0	0	0	0	0	6
580	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	3
590	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
600	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1
TOTALS	0	0	12	35	0	42	31	82	13	29	34	124	0	7	0	4	0	0	90	323

LAKE MICHIGAN - SURFACE GILL NETS

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
480	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
490	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2

Appendix 7. Continued.

ALEWIFE

PIGEON LAKE - SEINES

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
20	0	0	0	0	0	0	0	0	0	11	0	3	0	0	0	0	0	0	0	14
30	0	0	0	0	0	0	0	0	2102	1871	9	62	1	2	0	0	0	0	2112	1935
40	0	0	0	0	0	0	0	0	285	556	4	256	0	1	0	0	0	0	289	813
50	0	0	0	0	0	0	0	0	3	0	0	10	0	0	0	0	0	0	3	10
170	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2
TOTALS	0	0	0	0	0	1	0	1	2390	2438	13	331	1	3	0	0	0	0	2404	2774

RAINBOW SMELT

PIGEON LAKE - SEINES

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
30	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
50	0	0	0	1	0	0	0	0	0	0	0	0	1	3	0	0	0	0	1	4
60	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	2
70	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	1	3	0	0	0	0	5	0	0	0	1	5	0	0	0	0	7	8

SPOTTAIL SHINER

PIGEON LAKE - SEINES

LENGTH	APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC		SUM	
INTERVAL	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT	DAY	NGT
10	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0
20	0	0	1	0	0	0	0	0	41	3	402	4	0	0	0	0	0	0	444	7
30	0	4	0	0	0	0	0	0	42	0	1506	10	2	0	8	17	0	0	1558	31
40	0	9	3	6	0	0	0	0	108	11	363	5	1	11	14	14	0	0	489	56
50	0	4	3	4	2	4	0	0	8	17	1	2	0	11	3	7	0	0	17	49
60	0	0	8	30	2	1	0	0	0	0	3	0	0	4	2	2	0	0	15	37
70	0	2	13	37	1	2	0	0	1	3	0	0	0	1	0	2	0	0	15	47
80	0	0	16	77	0	16	1	4	0	0	0	0	0	0	2	2	0	0	19	99
90	0	1	1	70	0	41	1	38	0	1	0	0	0	0	0	0	0	0	2	151
100	0	0	0	50	0	23	0	33	0	0	1	0	0	0	1	0	0	0	2	106
110	0	0	1	28	0	3	0	2	0	0	0	0	0	0	0	0	0	0	1	33
120	0	0	0	10	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	13
130	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
150	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	20	46	312	5	92	2	80	201	35	2276	21	3	27	30	44	0	0	2563	631

Appendix 7. Continued.

YELLOW PERCH

Pigeon Lake - Seines

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
20	0	0	0	0	3763	257	0	0	1	0	0	0	0	0	0	0	0	0	3764	257
30	0	0	0	0	1138	173	5	153	1	0	0	0	0	0	0	0	0	0	1144	326
40	0	0	0	0	0	0	148	1048	9	0	6	5	0	0	0	1	0	0	163	1054
50	0	0	0	0	0	0	47	81	30	165	14	1	0	1	0	0	0	0	91	248
60	0	0	0	1	0	0	0	0	70	98	63	36	1	8	0	1	0	0	134	144
70	0	0	0	6	0	0	0	0	109	11	167	77	2	19	0	3	0	0	278	116
80	0	0	1	18	1	2	0	1	0	0	80	24	0	11	0	2	0	0	82	58
90	0	0	2	2	22	2	0	2	0	1	14	1	0	4	0	1	0	0	38	13
100	0	0	0	0	5	1	0	6	0	1	0	0	0	1	0	0	0	0	5	9
110	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2	1
120	0	0	0	3	0	0	0	2	0	3	0	2	0	0	0	0	0	0	0	10
130	0	0	6	4	7	1	1	2	0	0	1	2	0	0	0	0	0	0	15	9
140	0	1	5	10	10	3	3	5	0	0	2	0	1	0	0	0	0	0	21	19
150	0	0	8	7	14	5	2	16	0	4	2	0	0	0	0	0	0	0	26	32
160	0	0	8	1	17	3	2	22	1	0	4	3	0	0	0	2	0	0	32	31
170	0	0	0	1	0	2	1	8	4	2	1	5	0	2	0	0	0	0	6	20
180	0	0	1	0	6	0	3	0	1	3	1	3	0	5	0	2	0	0	12	13
190	0	0	0	0	0	0	1	1	0	1	1	6	0	4	0	0	0	0	2	12
200	0	0	0	0	0	0	0	0	0	1	0	4	0	0	0	1	0	0	0	6
210	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	2
TOTALS	0	1	31	54	4984	449	214	1347	226	290	356	170	4	55	0	14	0	0	5815	2380

Pigeon Lake - Bottom Gill Nets

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
140	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
TOTALS	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0

TROUT-PERCH

Pigeon Lake - Seines

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
40	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	3
50	0	0	0	0	0	0	0	1	0	0	0	2	0	1	0	0	0	0	0	4
60	0	0	0	0	0	0	0	0	0	0	0	4	0	13	0	0	0	0	0	17
70	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0	0	0	0	0	5
80	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
TOTALS	0	0	0	0	0	0	0	1	0	0	0	7	0	22	0	0	0	0	0	30

Appendix 7. Continued.

PIGEON LAKE - SEINES

JOHNNY DARTER

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
10	0	0	0	0	29	0	0	0	0	0	0	0	0	0	0	0	0	0	29	0
20	0	0	0	0	33	0	2	0	0	0	0	0	0	0	0	0	0	0	35	0
30	0	0	1	0	0	1	4	34	2	9	2	0	0	5	2	1	0	0	11	50
40	1	2	4	13	0	6	8	15	20	10	10	40	1	11	0	6	0	0	44	103
50	2	4	0	10	2	0	7	11	1	8	15	54	3	30	1	13	0	0	31	130
60	0	0	0	6	3	3	3	4	0	1	1	14	0	8	0	0	0	0	7	36
70	1	1	1	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	2	4
80	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
TOTALS	4	7	6	30	67	10	24	64	23	28	28	109	4	56	3	20	0	0	159	324

PIGEON LAKE - SEINES

BLUEGILL

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
20	0	0	0	0	0	0	0	0	6	7	10	23	2	3	0	0	0	0	18	33
30	0	0	0	0	0	0	0	0	4	2	119	312	24	51	0	4	0	0	147	369
40	0	0	0	0	0	0	0	0	0	0	3	0	2	13	0	4	0	0	5	17
50	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
TOTALS	0	0	0	0	0	0	0	0	10	9	132	335	28	69	0	8	0	0	170	421

PIGEON LAKE - SEINES

WHITE SUCKER

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
40	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
50	0	0	0	0	0	0	2	5	0	0	0	0	0	0	0	0	0	0	2	5
60	0	0	0	0	0	0	1	5	0	0	0	0	0	0	0	0	0	0	1	5
70	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
90	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2
120	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
170	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
320	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
380	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTALS	0	0	0	1	0	2	3	14	0	0	0	2	0	0	0	0	0	0	3	19

PIGEON LAKE - SEINES

BLUNTNOSE MINNOW

LENGTH INTERVAL	APR DAY	APR NGT	MAY DAY	MAY NGT	JUN DAY	JUN NGT	JUL DAY	JUL NGT	AUG DAY	AUG NGT	SEP DAY	SEP NGT	OCT DAY	OCT NGT	NOV DAY	NOV NGT	DEC DAY	DEC NGT	SUM DAY	SUM NGT
20	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
30	0	0	0	0	0	0	0	0	4	20	5	5	1	0	2	1	0	0	12	26
40	0	1	0	16	0	0	0	0	26	139	22	6	0	2	4	9	0	0	52	173
50	0	0	4	24	0	3	6	6	1	1	46	5	0	0	1	0	0	0	58	39
60	0	2	4	3	0	2	0	7	17	5	8	0	0	0	0	1	0	0	29	20
70	0	1	0	2	0	1	0	1	0	1	2	1	0	2	0	1	0	0	2	10
80	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
TOTALS	0	4	8	45	0	6	6	14	48	167	83	17	2	4	7	12	0	0	154	269

APPENDIX 8

Appendix 8. Length-frequency distributions of fish collected during weekly impingement sampling, January-December 1979, at the J. H. Campbell Plant (Ottawa County, Michigan). Distributions were separated by four sampling periods (day, dusk, night, dawn), totaled over 24 h (TOT) and the number of fish collected per hour (T/24) calculated. LINTV = length-frequency interval.

ALEWIFE

	AL JAN 9						AL JAN 17						AL JAN 22						AL JAN 29					
LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)
60	2	1	2	0	5	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
70	2	2	6	4	14	0	33	5	2	3	43	1	5	16	6	11	38	1	0	0	0	0	0	0
80	2	0	3	4	9	0	33	13	6	6	58	2	3	32	10	10	55	2	0	0	0	0	0	0
90	0	0	0	2	2	0	0	4	1	3	8	0	6	64	2	1	73	3	0	1	1	0	2	0
100	0	0	0	2	2	0	0	2	0	0	2	0	0	0	0	2	2	0	0	0	0	0	0	0
TOTAL	6	3	11	12	32	1	66	25	9	12	112	4	14	112	18	24	168	7	0	1	1	0	2	0

	AL FEB 5						AL FEB 12						AL FEB 19						AL FEB 28					
LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	0	1	2	3	0	0	0	0	0	0	0	0	0	4	0	4	0	1	0	0	0	1	0
80	0	1	0	5	6	0	1	1	0	3	5	0	4	7	6	1	18	0	0	1	0	0	1	0
90	1	0	1	2	4	0	1	1	4	1	7	0	2	4	2	0	8	0	0	0	0	0	0	0
100	0	0	0	1	1	0	0	0	1	0	1	0	1	1	1	0	3	0	0	1	0	0	1	0
110	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	1	2	11	15	0	2	2	5	4	13	0	7	12	13	1	33	1	1	2	0	0	3	0

	AL MAR 5					
LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
90	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

	AL MAY 17						AL MAY 23						AL MAY 30					
LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)
80	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0
90	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
120	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
140	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	3	0
150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
160	0	0	0	0	0	0	0	0	0	5	5	0	1	0	2	1	4	0
170	0	0	0	0	0	0	0	0	0	11	11	0	1	1	1	0	3	0
180	2	0	0	0	2	0	1	0	0	11	12	0	1	2	2	1	6	0
190	0	0	0	0	0	0	2	0	2	7	11	0	2	2	1	1	6	0
200	0	1	0	0	1	0	0	0	0	2	2	0	0	0	0	0	0	0
210	0	0	0	0	0	0	0	0	0	3	3	0	0	0	0	1	1	0
TOTAL	2	1	0	1	4	0	3	0	2	39	44	1	5	7	11	6	29	1

Appendix 8. Continued.

	AL JUN 7						AL JUN 14						AL JUN 19						AL JUN 28					
LINIV	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)
80	1	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	1	0	1	0	0	2	0	0	2	0	0	0	0	0	0	0
110	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	1	2	0	0	0	0	0	0	0
120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	1	1	0
130	1	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	2	0	0	0	0	0	0	0
140	1	0	0	0	1	0	0	0	0	0	0	0	1	2	0	0	3	0	0	2	1	1	4	0
150	1	0	0	1	2	0	0	0	0	0	0	0	6	0	0	0	6	0	0	2	3	1	6	0
160	0	0	1	0	1	0	0	0	0	0	0	0	24	21	7	12	64	2	0	2	5	0	7	0
170	1	0	0	1	2	0	3	1	3	0	7	0	70	52	36	30	188	7	0	6	10	35	51	2
180	0	2	1	1	4	0	3	2	2	0	7	0	80	92	42	71	285	11	0	18	30	69	117	4
190	0	0	2	1	3	0	3	2	2	0	7	0	82	35	7	36	160	6	0	10	11	98	119	4
200	3	0	0	0	3	0	1	0	1	0	2	0	18	16	20	15	69	2	0	7	7	19	33	1
210	0	0	0	0	0	0	0	0	1	0	1	0	0	4	0	5	9	0	0	0	0	3	3	0
220	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2	0
TOTAL	8	3	5	5	21	0	10	5	10	0	25	1	282	226	114	170	792	33	0	48	67	228	343	14

	AL JUL 4						AL JUL 10						AL JUL 19						AL JUL 25					
LINIV	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
90	0	2	1	3	6	0	0	0	1	0	1	0	0	0	1	0	1	0	0	0	1	0	1	0
100	1	1	2	1	5	0	0	0	1	0	1	0	0	0	1	0	1	0	0	0	1	0	1	0
110	5	3	3	1	12	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
120	3	2	3	1	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130	4	1	1	2	8	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	1	0
140	2	0	2	1	5	0	0	0	0	2	2	0	1	0	1	0	2	0	0	0	0	1	1	0
150	0	0	2	2	4	0	2	2	0	0	4	0	0	0	1	0	1	0	0	0	0	2	2	0
160	8	11	16	2	37	1	5	0	0	1	6	0	3	3	6	0	12	0	0	0	1	0	1	0
170	17	34	37	26	114	4	15	13	23	8	59	2	14	5	8	6	33	1	1	1	2	1	5	0
180	81	86	111	33	311	12	27	10	16	8	61	2	41	15	24	10	90	3	3	5	5	2	15	0
190	64	30	42	20	156	6	5	9	13	6	33	1	19	8	6	7	40	1	3	5	2	0	10	0
200	10	11	25	7	53	2	7	4	14	6	31	1	5	4	6	0	15	0	0	0	0	1	1	0
210	3	4	11	3	21	0	3	0	2	0	5	0	0	0	0	2	2	0	1	0	0	0	1	0
220	0	2	2	1	5	0	2	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	198	187	261	103	749	31	66	39	70	31	206	8	84	35	55	25	199	8	9	11	12	7	39	1

	AL AUG 1						AL AUG 7						AL AUG 14						AL AUG 21					
LINIV	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)
20	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	1	16	4	10	31	1	13	6	0	2	21	0
40	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	1	6	0	9	3	4	0	16	0
100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
160	0	2	1	1	4	0	0	0	0	0	0	0	0	2	0	0	2	0	0	1	0	0	1	0
170	2	2	2	1	7	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
180	3	6	6	1	16	0	1	0	0	0	1	0	0	1	1	1	3	0	0	0	2	0	2	0
190	1	2	2	0	5	0	1	0	0	0	1	0	0	2	0	1	3	0	1	1	1	0	3	0
200	1	0	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
220	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	7	12	14	3	36	1	2	0	0	0	2	0	1	29	6	14	50	2	23	11	7	2	43	1

Appendix 8. Continued.

AL AUG 29

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
20	0	5	0	0	5	0
30	13	38	7	151	209	9
40	9	21	2	46	78	3
50	3	2	1	7	13	C
60	0	0	0	1	1	0
100	0	0	0	0	0	0
130	0	0	C	0	0	0
160	0	C	0	0	0	0
170	1	0	0	0	1	0
180	0	C	0	0	0	0
190	0	0	0	0	0	0
200	0	0	0	0	0	0
220	0	0	0	0	C	C
TOTAL	26	66	10	205	3C7	12

AL SEP 5

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
20	5	0	0	0	5	C
30	46	109	42	12	209	8
40	10	73	23	23	129	5
50	0	0	0	1	1	0
60	0	0	0	0	0	0
70	0	0	0	0	0	0
80	0	0	0	0	0	0
180	1	0	1	0	2	0
TOTAL	62	182	66	36	346	14

AL SEP 12

LINTV	ONE 24-HR SAMPLE	(TOT	I/24)
20	0	0	0
30	145	145	6
40	207	207	8
50	34	34	1
60	9	9	0
70	8	8	0
80	3	3	0
180	0	0	0
TOTAL	406	406	16

AL SEP 18

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
20	0	0	0	0	0	0
30	57	0	0	10	67	2
40	157	36	19	135	347	14
50	6	6	10	6	28	1
60	1	1	1	0	3	0
70	0	1	0	0	1	0
80	0	0	0	0	0	0
180	0	0	0	0	0	0
TOTAL	221	44	30	151	446	18

AL SEP 26

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
20	0	0	0	0	0	0
30	1	0	1	0	2	0
40	10	2	1	3	16	0
50	2	1	1	3	7	0
60	0	0	0	0	0	0
70	0	0	0	0	0	0
80	0	1	1	0	2	0
180	0	0	0	0	0	0
TOTAL	13	4	4	6	27	1

AL OCT 2

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
30	0	0	0	0	C	0
40	1	4	11	3	19	0
50	0	0	8	1	9	0
60	0	C	2	0	2	0
70	0	3	1	0	4	0
80	0	1	1	0	2	0
170	0	0	0	0	0	0
180	0	0	0	0	0	0
TOTAL	1	8	23	4	36	1

AL OCT 8

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
30	0	2	0	1	3	0
40	1	4	1	1	7	0
50	1	2	4	0	7	0
60	0	0	0	1	1	0
70	0	0	0	1	1	0
80	0	0	0	0	0	0
170	0	0	0	0	0	0
180	C	0	0	0	0	0
TOTAL	2	8	5	4	19	0

AL OCT 18

LINTV	ONE 24-HR SAMPLE	(TOT	I/24)
30	45	45	1
40	108	108	4
50	49	49	2
60	1	1	0
70	1	1	0
80	0	0	0
170	2	2	0
180	1	1	0
TOTAL	207	207	8

AL OCT 24

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
30	118	5	17	6	146	6
40	471	174	144	32	821	34
50	65	85	110	40	300	12
60	5	3	16	1	25	1
70	0	1	0	1	2	0
80	0	0	0	0	0	0
170	0	0	0	0	0	0
180	0	0	0	0	0	0
TOTAL	659	268	287	80	1294	53

AL OCT 30

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
30	0	18	0	1	19	0
40	18	132	20	2	172	7
50	3	70	7	2	82	3
60	1	0	0	0	1	C
70	0	0	0	0	0	0
80	0	0	0	0	0	0
170	0	C	0	0	0	C
180	C	C	C	0	0	C
TOTAL	22	220	27	5	274	11

AL NOV 7

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
30	0	0	2	0	2	0
40	129	53	88	216	486	20
50	183	48	147	79	457	19
60	8	13	12	0	33	1
70	0	0	0	1	1	C
80	0	0	0	1	1	C
90	0	0	0	0	0	0
TOTAL	320	114	249	297	980	4C

AL NOV 14

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
30	0	0	C	0	0	0
40	216	45	27	71	359	14
50	17	104	59	10	190	7
60	3	8	4	3	18	0
70	1	1	2	0	4	0
80	0	0	0	0	0	0
90	0	0	0	0	0	0
TOTAL	237	158	92	84	571	23

AL NOV 20

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
30	0	2	0	0	2	0
40	37	26	30	78	171	7
50	26	53	13	91	183	7
60	2	5	2	2	11	0
70	1	1	1	0	3	0
80	0	0	0	0	0	0
90	0	0	0	0	0	0
TOTAL	66	87	46	171	370	15

AL NOV 26

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
30	0	0	0	0	0	0
40	86	64	54	30	234	9
50	374	351	213	68	1006	41
60	47	45	34	14	140	5
70	7	10	10	2	29	1
80	4	2	3	1	10	0
90	0	2	1	0	3	0
TOTAL	518	474	315	115	1422	59

AL DEC 4

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
40	2	0	2	0	4	C
50	3	1	5	2	11	0
60	1	1	1	0	3	C
70	0	1	0	0	1	0
80	0	0	1	0	1	0
90	0	0	0	1	1	0
100	0	C	0	0	0	C
110	0	0	0	0	0	0
TOTAL	6	3	9	3	21	0

AL DEC 10

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
40	4	0	0	0	4	0
50	39	2	4	5	50	2
60	5	1	0	0	6	0
70	2	1	0	1	4	0
80	2	0	C	0	2	0
90	2	0	C	0	2	0
100	1	0	0	0	1	0
110	C	0	C	0	0	0
TOTAL	55	4	4	6	69	2

Appendix 8. Continued.

LINTV	AL DEC 17 DAY	DSK	NGT	DWN	(TOT	T/24)	AL DEC 27 DAY	DSK	NGT	DWN	(TOT	T/24)
40	3	3	0	1	7	0	0	0	0	0	0	0
50	48	16	7	0	71	2	3	0	0	1	4	0
60	11	10	4	0	25	1	1	2	0	1	4	0
70	2	4	1	1	8	0	0	2	0	4	6	0
80	2	2	2	1	7	0	0	3	0	0	3	0
90	1	6	2	1	10	0	0	0	1	0	1	0
100	6	2	3	1	12	0	0	0	0	0	0	0
110	5	1	0	0	6	0	0	0	0	0	0	0
TOTAL	78	44	19	5	146	6	4	7	1	6	18	0

BLACK BULLHEAD

BB JAN 17

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
80	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

LINTV	BB APR 7 DAY	DSK	NGT	DWN	(TOT	T/24)	BB APR 11 DAY	DSK	NGT	DWN	(TOT	T/24)	BB APR 16 DAY	DSK	NGT	DWN	(TOT	T/24)
130	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
180	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
210	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
240	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	1	0	0	1	0	0	0	2	0	2	0	1	0	0	0	1	0

LINTV	BB JUN 15 DAY	DSK	NGT	DWN	(TOT	T/24)	BB JUN 28 DAY	DSK	NGT	DWN	(TOT	T/24)
160	0	0	1	0	1	0	0	0	0	0	0	0
190	0	0	0	0	0	0	0	0	0	1	1	0
TOTAL	0	0	1	0	1	0	0	0	0	1	1	0

BB JUL 4

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
160	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

BB NOV 26

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
140	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

BB DEC 27

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
140	0	1	0	0	1	0
180	0	1	0	0	1	0
TOTAL	0	2	0	0	2	0

Appendix 8. Continued.

BLACK CRAPPIE

BC JAN 9

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	1	0	2	0	3	0
70	0	2	0	0	2	0
80	0	0	0	0	0	0
140	0	0	0	0	0	0
150	0	0	0	0	0	0
TOTAL	1	2	2	0	5	0

BC JAN 17

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	0	0	0	0	0	0
70	1	0	2	0	3	0
80	0	1	0	0	1	0
140	1	1	0	1	3	0
150	0	1	0	0	1	0
TOTAL	2	3	2	1	8	0

BC JAN 22

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	0	0	0	0	0	0
70	0	2	0	0	2	0
80	0	0	0	0	0	0
140	1	0	0	0	1	0
150	0	0	0	0	0	0
TOTAL	1	2	0	0	3	0

BC FEB 5

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	0	0	0	0	0	0
90	0	0	0	0	0	0
140	0	0	0	0	0	0
240	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

BC FEB 13

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	0	0	0	0	0	0
90	0	0	0	1	1	0
140	0	0	0	1	1	0
240	0	0	0	0	0	0
TOTAL	0	0	0	2	2	0

BC FEB 28

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	1	0	0	0	1	0
90	0	0	0	0	0	0
140	0	0	0	0	0	0
240	0	0	0	0	0	0
TOTAL	1	0	0	0	1	0

BC MAR 6

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
70	0	0	0	0	0	0
80	0	0	0	1	1	0
TOTAL	0	0	0	1	1	0

BC MAR 14

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
70	0	1	0	1	2	0
80	0	0	0	0	0	0
TOTAL	0	1	0	1	2	0

BC APR 7

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	0	0	0	0	0	0
70	0	1	1	0	2	0
80	0	0	0	0	0	0
90	0	1	0	0	1	0
130	0	0	1	0	1	0
160	0	0	1	0	1	0
TOTAL	0	2	3	0	5	0

BC APR 11

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	0	1	1	0	2	0
70	1	1	5	0	7	0
80	0	0	1	0	1	0
90	0	0	0	1	1	0
130	0	0	0	0	0	0
160	0	0	0	0	0	0
TOTAL	1	2	7	1	11	0

BC APR 16

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	0	0	0	0	0	0
70	0	1	0	0	1	0
80	0	0	0	0	0	0
90	0	0	0	0	0	0
130	0	0	0	0	0	0
160	0	0	0	0	0	0
TOTAL	0	1	0	0	1	0

BC APR 25

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	0	0	0	0	0	0
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	1	0	0	0	1	0
130	0	0	0	0	0	0
160	0	0	0	0	0	0
TOTAL	1	0	0	0	1	0

BC MAY 2

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
70	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

BC MAY 18

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
70	0	0	0	1	1	0
TOTAL	0	0	0	1	1	0

BC JUN 15

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

BC JUL 10

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	1	0	0	1	0
90	0	0	3	0	3	0
TOTAL	0	1	3	0	4	0

BC AUG 15

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
100	0	0	0	1	1	0
210	0	0	0	0	0	0
TOTAL	0	0	0	1	1	0

BC AUG 21

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
100	0	0	0	0	0	0
210	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

BC OCT 24

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
50	1	0	0	0	1	0
70	1	0	0	0	1	0
80	0	0	0	0	0	0
TOTAL	2	0	0	0	2	0

BC OCT 30

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
50	0	0	0	0	0	0
70	0	0	0	0	0	0
80	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

Appendix 8. Continued.

BC NOV 20

LINTV	DAY	DSK	NGI	DWN	TOT	I/24
110	0	0	0	1	1	0
130	0	1	0	0	1	0
TOTAL	0	1	0	1	2	0

BC DEC 4

LINTV	DAY	DSK	NGI	DWN	TOT	I/24
50	0	0	0	0	0	0
60	0	0	1	0	1	0
100	0	0	1	0	1	0
140	0	0	0	0	0	0
TOTAL	0	0	2	0	2	0

BC DEC 10

LINTV	DAY	DSK	NGI	DWN	TOT	I/24
50	1	0	0	0	1	0
60	1	0	0	0	1	0
100	0	0	0	0	0	0
140	0	0	0	0	0	0
TOTAL	2	0	0	0	2	0

BC DEC 17

LINTV	DAY	DSK	NGI	DWN	TOT	I/24
50	1	0	0	0	1	0
60	1	0	1	0	2	0
100	0	0	0	0	0	0
140	0	0	0	0	0	0
TOTAL	2	0	1	0	3	0

BC DEC 27

LINTV	DAY	DSK	NGI	DWN	TOT	I/24
50	0	0	0	0	0	0
60	0	0	0	0	0	0
100	0	0	0	0	0	0
140	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

BLUEGILL

BG JAN 9

LINTV	DAY	DSK	NGI	DWN	TOT	I/24
50	1	0	0	0	1	0
100	0	0	0	0	0	0
TOTAL	1	0	0	0	1	0

BG JAN 17

LINTV	DAY	DSK	NGI	DWN	TOT	I/24
50	0	0	0	0	0	0
100	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

BG APR 7

LINTV	DAY	DSK	NGI	DWN	TOT	I/24
90	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

BG OCT 24

LINTV	DAY	DSK	NGI	DWN	TOT	I/24
50	3	3	0	1	7	0
60	0	0	0	0	0	0
70	0	1	0	0	1	0
80	0	0	1	0	1	0
TOTAL	3	4	1	1	9	0

BG OCT 30

LINTV	DAY	DSK	NGI	DWN	TOT	I/24
50	0	0	0	1	1	0
60	1	0	0	0	1	0
70	0	1	0	0	1	0
80	0	0	0	0	0	0
TOTAL	1	1	0	1	3	0

BG NOV 7

LINTV	DAY	DSK	NGI	DWN	TOT	I/24
50	1	0	0	0	1	0
60	1	0	1	0	2	0
70	1	0	0	0	1	0
TOTAL	3	0	1	0	4	0

BG NOV 26

LINTV	DAY	DSK	NGI	DWN	TOT	I/24
50	0	0	0	0	0	0
60	0	1	1	0	2	0
70	0	0	0	0	0	0
TOTAL	0	1	1	0	2	0

BG DEC 4

LINTV	DAY	DSK	NGI	DWN	TOT	I/24
50	1	1	0	0	2	0
TOTAL	1	1	0	0	2	0

Appendix 8. Continued.

BOWFIN

BF MAR 14

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
510	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

BF APR 12

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
460	0	0	0	1	1	0
TOTAL	0	0	0	1	1	0

BF AUG 1

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
470	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

BROWN BULLHEAD

BT FEB 5

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
150	1	0	0	0	1	0
190	1	0	0	0	1	0
TOTAL	2	0	0	0	2	0

BN OCT 24

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
170	0	1	0	0	1	0
310	0	0	0	0	0	0
TOTAL	0	1	0	0	1	0

BN OCT 30

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
170	0	0	0	0	0	0
310	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

BN DEC 10

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
50	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

BN MAR 14

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
40	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

BROWN TROUT

BN NOV 26

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
160	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

BT APR 11

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
230	0	0	1	0	1	0
450	0	0	0	0	0	0
TOTAL	0	0	1	0	1	0

BT APR 16

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
230	0	0	0	0	0	0
450	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

BT AUG 30

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
140	0	0	0	1	1	0
TOTAL	0	0	0	1	1	0

BURBOT

BR JAN 17

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
210	0	0	0	0	0	0
290	0	0	0	0	0	0
340	0	0	0	0	0	0
370	0	0	0	2	2	0
440	1	0	0	0	1	0
470	0	0	0	1	1	0
TOTAL	1	0	0	3	4	0

BR JAN 22

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
210	1	0	0	0	1	0
290	0	0	0	0	0	0
340	0	0	0	1	1	0
370	0	0	0	0	0	0
440	0	0	0	0	0	0
470	0	0	0	0	0	0
TOTAL	1	0	0	1	2	0

BR JAN 29

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
210	0	0	0	0	0	0
290	0	1	0	0	1	0
340	0	0	0	0	0	0
370	0	0	0	0	0	0
440	0	0	0	0	0	0
470	0	0	0	0	0	0
TOTAL	0	1	0	0	1	0

Appendix 8. Continued.

LINTV	BR FEB 5 DAY	DSK	NGT	DWN	(TOT	T/24)	BR FEB 12 DAY	DSK	NGT	DWN	(TOT	T/24)	BR FEB 28 DAY	DSK	NGT	DWN	(TOT	T/24)
270	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
310	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
360	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
370	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
380	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	3	0	1	4	0	0	1	0	0	1	0	0	0	1	0	1	0

LINTV	BR MAR 14 DAY	DSK	NGT	DWN	(TOT	T/24)	BR MAR 28 DAY	DSK	NGT	DWN	(TOT	T/24)
320	0	0	0	0	0	0	0	0	1	0	1	0
390	1	0	0	0	1	0	0	0	0	0	0	0
TOTAL	1	0	0	0	1	0	0	0	1	0	1	0

LINTV	BR APR 11 DAY	DSK	NGT	DWN	(TOT	T/24)	BR APR 17 DAY	DSK	NGT	DWN	(TOT	T/24)	BR APR 25 DAY	DSK	NGT	DWN	(TOT	T/24)
200	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
210	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
450	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0	0	0	0	1	1	0	0	1	0	0	1	0

BR MAY 24

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
170	0	0	0	1	1	0
TOTAL	0	0	0	1	1	0

BR OCT 18

LINTV	ONE 24-HR SAMPLE	(TOT	T/24)
530	1	1	0
TOTAL	1	1	0

CARP

CP NOV 8

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
90	0	0	0	1	1	0
TOTAL	0	0	0	1	1	0

Appendix 8. Continued.

CHANNEL CATFISH

CC JAN 9

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
60	0	1	0	0	1	0
70	0	0	0	0	0	0
80	0	0	0	1	1	0
TOTAL	0	1	0	1	2	0

CC JAN 17

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
60	0	0	0	0	0	0
70	0	0	0	0	0	0
80	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

CC JAN 23

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
60	0	0	0	0	0	0
70	0	0	0	1	1	0
80	0	0	0	0	0	0
TOTAL	0	0	0	1	1	0

CC MAR 5

LINTV	DAY	DSK	AGT	DWN	(TOT	T/24)
60	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

CC APR 11

LINTV	DAY	DSK	AGT	DWN	(TOT	T/24)
90	0	0	1	0	1	0
410	0	0	0	1	1	0
TOTAL	0	0	1	1	2	0

CC SEP 26

LINTV	DAY	DSK	AGT	DWN	(TOT	T/24)
60	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

CC DEC 17

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
440	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

CHINOOK SALMON

CH MAR 5

LINTV	DAY	DSK	AGT	DWN	(TOT	T/24)
250	0	0	0	0	0	0
260	0	1	0	0	1	0
330	0	0	0	0	0	0
TOTAL	0	1	0	0	1	0

CH MAR 14

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
250	0	0	1	0	1	0
260	0	0	0	0	0	0
330	0	0	0	0	0	0
TOTAL	0	0	1	0	1	0

CH MAR 21

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
250	0	0	0	0	0	0
260	0	0	0	0	0	0
330	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

CH APR 7

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
260	1	1	0	0	2	0
270	0	0	0	0	0	0
300	0	0	1	0	1	0
330	0	0	0	0	0	0
TOTAL	1	1	1	0	3	0

CH APR 11

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
260	0	0	0	0	0	0
270	1	0	0	0	1	0
300	1	0	0	0	1	0
330	1	0	0	0	1	0
TOTAL	3	0	0	0	3	0

CH APR 16

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
260	0	0	0	0	0	0
270	0	0	0	0	0	0
300	1	0	1	0	2	0
330	0	0	0	0	0	0
TOTAL	1	0	1	0	2	0

CH MAY 2

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
130	0	0	0	0	0	0
270	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

CH MAY 30

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
130	0	0	1	0	1	0
270	0	0	0	0	0	0
TOTAL	0	0	1	0	1	0

Appendix 8. Continued.

CH JUL 10

LINTV	DAY	DSK	NGT	DWN	TOT	I/24
100	1	0	0	0	1	0
110	0	0	0	0	0	0
TOTAL	1	0	0	0	1	0

CH JUL 19

LINTV	DAY	DSK	NGT	DWN	TOT	I/24
100	0	0	0	0	0	0
110	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

CH AUG 22

LINTV	DAY	DSK	NGT	DWN	TOT	I/24
150	0	0	0	1	1	0
TOTAL	0	0	0	1	1	0

CH OCT 18

LINTV	ONE 24-HR SAMPLE	TOT	I/24
360	1	1	0
TOTAL	1	1	0

CH NOV 14

LINTV	DAY	DSK	NGT	DWN	TOT	I/24
380	0	0	0	0	0	0
400	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

CH NOV 20

LINTV	DAY	DSK	NGT	DWN	TOT	I/24
380	1	0	0	0	1	0
400	0	0	0	0	0	0
TOTAL	1	0	0	0	1	0

CH NOV 26

LINTV	DAY	DSK	NGT	DWN	TOT	I/24
380	1	0	0	0	1	0
400	0	0	0	0	0	0
TOTAL	1	0	0	0	1	0

CH DEC 17

LINTV	DAY	DSK	NGT	DWN	TOT	I/24
190	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

COHO SALMON

CM JAN 3

LINTV	DAY	DSK	NGT	DWN	TOT	I/24
370	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

CM APR 25

LINTV	DAY	DSK	NGT	DWN	TOT	I/24
400	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

CM MAY 30

LINTV	DAY	DSK	NGT	DWN	TOT	I/24
200	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

CM AUG 21

LINTV	DAY	DSK	NGT	DWN	TOT	I/24
170	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

CM OCT 18

LINTV	ONE 24-HR SAMPLE	TOT	I/24
350	1	1	0
TOTAL	1	1	0

COMMON SHINER

CS JUN 28

LINTV	DAY	DSK	NGT	DWN	TOT	I/24
130	0	0	0	1	1	0
TOTAL	0	0	0	1	1	0

Appendix 8. Continued.

EMERALD SHINER

ES FEB 12

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
80	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

ES MAR 5

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
80	1	0	0	0	1	0
90	3	0	0	0	3	0
TOTAL	4	0	0	0	4	0

ES MAR 14

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
80	0	0	0	0	0	0
90	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

ES MAR 28

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
80	0	1	0	0	1	0
90	0	0	0	0	0	0
TOTAL	0	1	0	0	1	0

ES APR 11

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
90	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

ES MAY 17

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
110	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

ES SEP 12

LINTV	ONE 24-HR SAMPLE	(TOT	T/24)
80	1	1	0
TOTAL	1	1	0

FATHEAD MINNOW

PP JAN 29

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
60	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

PP MAR 21

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

PP APR 7

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	0	1	0	1	0
80	0	1	0	1	2	0
TOTAL	0	1	1	1	3	0

FLATHEAD CATFISH

FC APR 11

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
380	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

GIZZARD SHAD

LINTV	GS JAN 3 DAY	DSK	NGT	DWN	(TOT	I/24)	GS JAN 9 DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	0	0	0	0	0	0	0	0	0	0	0
90	1	0	0	0	1	0	0	0	0	0	0	0
100	3	0	0	0	3	0	0	0	0	0	0	0
110	1	0	0	0	1	0	0	1	1	0	2	0
120	13	0	1	0	14	0	0	0	0	0	0	0
130	4	3	0	0	7	0	0	0	0	0	0	0
140	4	4	1	2	11	0	1	1	3	0	5	0
150	33	14	1	1	49	2	1	0	0	2	3	0
160	30	9	1	6	46	1	0	1	0	0	1	0
170	19	14	2	2	37	1	0	0	1	1	2	0
180	17	3	0	1	21	0	0	0	0	0	0	0
190	0	0	0	0	0	0	0	0	0	0	0	0
200	1	0	0	0	1	0	0	0	0	0	0	0
210	0	0	0	0	0	0	0	0	0	0	0	0
220	0	0	0	0	0	0	0	0	0	0	0	0
280	0	0	0	0	0	0	0	0	0	0	0	0
300	0	0	0	0	0	0	0	0	0	0	0	0
310	0	0	0	0	0	0	1	0	0	0	1	0
340	0	0	0	0	0	0	0	0	0	0	0	0
350	1	0	0	0	1	0	0	0	0	0	0	0
TOTAL	127	47	6	12	192	8	3	3	5	3	14	0

LINTV	GS JAN 17 DAY	DSK	NGT	DWN	(TOT	I/24)	GS JAN 22 DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	0	0	0	0	0	1	0	0	0	1	0
90	69	2	0	0	71	2	0	0	0	1	1	0
100	102	4	3	1	110	4	1	6	2	2	11	0
110	62	15	3	5	85	3	8	9	7	12	36	1
120	93	11	4	15	123	5	19	11	2	12	44	1
130	31	54	4	8	97	4	50	22	6	39	117	4
140	137	61	10	35	243	10	69	230	5	93	397	16
150	192	95	8	17	312	13	180	40	134	63	417	17
160	98	39	7	12	156	6	129	100	109	79	417	17
170	102	10	7	17	136	5	49	40	3	23	115	4
180	29	13	2	14	58	2	38	12	3	0	53	2
190	0	3	0	6	9	0	2	2	2	0	6	0
200	0	0	0	0	0	0	1	0	2	1	4	0
210	1	0	0	2	3	0	1	0	0	0	1	0
220	2	0	0	0	2	0	1	0	0	0	1	0
280	0	0	0	0	0	0	0	0	1	0	1	0
300	1	0	0	0	1	0	0	0	0	0	0	0
310	0	0	0	0	0	0	0	0	0	0	0	0
340	1	0	0	0	1	0	0	0	0	0	0	0
350	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	920	307	48	132	1407	58	549	472	276	325	1622	67

LINTV	GS JAN 29 DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	1	0	1	2	0
90	1	0	0	0	1	0
100	0	0	0	0	0	0
110	1	4	0	0	5	0
120	11	5	0	0	16	0
130	11	3	0	1	15	0
140	7	5	3	3	18	0
150	10	0	2	3	15	0
160	17	14	4	1	36	1
170	4	5	6	1	16	0
180	3	1	0	0	4	0
190	1	1	0	0	2	0
200	0	1	1	0	2	0
210	0	0	0	0	0	0
220	0	0	0	0	0	0
280	0	0	0	0	0	0
300	0	0	0	0	0	0
310	0	0	0	0	0	0
340	0	0	0	0	0	0
350	0	0	0	0	0	0
TOTAL	66	40	16	10	132	5

LINTV	GS FEB 5 DAY	DSK	NGT	DWN	(TOT	I/24)	GS FEB 12 DAY	DSK	NGT	DWN	(TOT	I/24)	GS FEB 19 DAY	DSK	NGT	DWN	(TOT	I/24)
100	0	0	1	0	1	0	0	0	0	0	0	0	0	2	0	0	2	0
110	1	0	0	1	2	0	2	4	0	0	6	0	0	0	0	0	0	0
120	2	4	5	1	12	0	2	2	3	1	8	0	2	2	1	0	5	0
130	16	18	11	11	56	2	13	3	4	3	23	0	0	7	11	0	18	0
140	18	30	20	15	83	3	15	11	7	2	35	1	28	8	9	0	45	1
150	51	42	19	23	135	5	29	16	9	4	58	2	28	23	26	2	79	3
160	38	38	12	32	120	5	4	1	0	4	9	0	34	21	35	5	95	3
170	33	8	12	11	64	2	0	4	3	1	8	0	34	23	11	0	68	2
180	6	9	3	0	18	0	2	2	0	0	4	0	34	15	5	0	54	2
190	5	3	0	1	9	0	1	0	0	0	1	0	5	2	4	0	11	0
200	6	0	0	1	7	0	0	0	1	0	1	0	2	2	0	0	4	0
210	2	0	0	0	2	0	0	0	0	1	1	0	3	1	0	0	4	0
220	1	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0
230	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
310	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
350	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
410	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
TOTAL	179	153	83	97	512	21	68	43	27	16	154	6	170	108	103	7	388	16

Appendix 8. Continued.

GS FEB 28

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
100	0	0	0	0	0	0
110	0	0	0	0	0	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
140	0	0	0	0	0	0
150	0	0	0	0	0	0
160	0	0	0	0	0	0
170	0	0	1	0	1	0
180	1	0	0	0	1	0
190	0	0	0	0	0	0
200	0	0	0	0	0	0
210	0	0	0	0	0	0
220	0	0	0	0	0	0
230	0	0	0	0	0	0
310	0	0	0	0	0	0
350	0	0	0	0	0	0
410	0	0	0	0	0	0
TOTAL	1	0	1	0	2	0

GS MAR 5

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
110	1	0	0	0	1	0
120	0	1	1	5	7	0
130	14	23	1	25	63	2
140	35	15	2	13	65	2
150	98	15	4	20	137	5
160	59	12	7	18	96	4
170	40	18	7	17	92	3
180	4	14	4	15	37	1
190	11	2	0	5	18	0
200	3	0	0	0	3	0
210	1	0	0	1	2	0
220	1	0	0	0	1	0
230	0	0	0	1	1	0
TOTAL	267	100	26	120	513	21

GS MAR 14

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
110	0	0	0	0	0	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
140	0	0	0	0	0	0
150	1	0	0	0	1	0
160	1	0	0	0	1	0
170	0	0	0	0	0	0
180	2	0	0	0	2	0
190	0	0	0	0	0	0
200	0	0	0	0	0	0
210	0	0	0	0	0	0
220	0	0	0	0	0	0
230	0	0	0	0	0	0
TOTAL	4	0	0	0	4	0

GS MAR 28

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
110	0	0	0	0	0	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
140	0	0	0	0	0	0
150	1	0	0	0	1	0
160	0	0	1	0	1	0
170	0	0	0	0	0	0
180	0	0	0	0	0	0
190	0	0	0	0	0	0
200	0	0	0	0	0	0
210	1	0	0	0	1	0
220	0	0	0	0	0	0
230	0	0	0	0	0	0
TOTAL	2	0	1	0	3	0

GS APR 7

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
120	1	1	1	0	3	0
130	0	0	0	0	0	0
140	0	0	0	0	0	0
150	0	0	2	0	2	0
160	2	0	1	0	3	0
170	0	2	0	0	2	0
180	0	0	0	0	0	0
190	0	0	0	0	0	0
200	0	0	0	1	1	0
210	0	0	0	0	0	0
240	0	0	0	0	0	0
TOTAL	3	3	4	1	11	0

GS APR 11

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
120	1	1	1	0	3	0
130	1	0	1	0	2	0
140	2	1	6	0	9	0
150	3	0	5	2	10	0
160	0	1	5	2	8	0
170	1	1	0	6	8	0
180	1	0	4	5	10	0
190	0	0	0	1	1	0
200	0	0	0	1	1	0
210	0	0	2	0	2	0
240	0	0	0	1	1	0
TOTAL	9	4	24	18	55	2

GS APR 16

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
120	1	0	0	0	1	0
130	0	0	0	0	0	0
140	0	0	1	0	1	0
150	0	0	0	0	0	0
160	0	0	0	0	0	0
170	0	0	0	0	0	0
180	0	0	0	0	0	0
190	0	0	0	0	0	0
200	0	0	0	0	0	0
210	0	0	0	0	0	0
240	0	0	0	0	0	0
TOTAL	1	0	1	0	2	0

GS MAY 2

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
150	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

GS JUL 4

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
160	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

GS AUG 7

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
60	0	0	0	0	0	0
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	0	0	0	0	0	0
100	0	0	0	0	0	0
120	0	0	0	0	0	0
130	1	0	0	0	1	0
140	0	0	0	0	0	0
150	0	0	0	0	0	0
TOTAL	1	0	0	0	1	0

GS AUG 14

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
60	0	0	1	0	1	0
70	0	1	0	0	1	0
80	3	0	3	3	9	0
90	1	0	5	1	7	0
100	0	1	0	1	2	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
140	0	0	0	0	0	0
150	0	0	0	0	0	0
TOTAL	4	2	9	5	20	0

GS AUG 21

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
60	0	0	0	0	0	0
70	1	0	0	0	1	0
80	1	0	1	1	3	0
90	0	0	2	1	3	0
100	0	0	0	0	0	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
140	0	0	0	0	0	0
150	0	0	0	0	0	0
TOTAL	2	0	3	2	7	0

GS AUG 29

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
60	0	0	0	0	0	0
70	1	0	0	15	16	0
80	0	0	1	3	4	0
90	0	0	1	0	1	0
100	0	0	0	0	0	0
120	1	0	0	0	1	0
130	0	0	0	0	0	0
140	0	0	0	1	1	0
150	0	0	0	1	1	0
TOTAL	2	0	2	20	24	1

Appendix 8. Continued.

LINTV	GS DEC 4 DAY	DSK	NGI	DWN	(TOT	I/24)	GS DEC 10 DAY	DSK	NGI	DWN	(TOT	I/24)	GS DEC 17 DAY	DSK	NGI	DWN	(TOT	I/24)	GS DEC 27 DAY	DSK	NGI	DWN	(TOT	I/24)
60	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70	1	0	1	0	2	0	3	0	0	0	3	0	11	4	0	0	15	0	1	0	0	0	1	0
80	2	0	0	1	3	0	2	2	1	0	5	0	6	21	7	1	35	1	1	0	0	0	1	0
90	0	0	3	1	4	0	2	1	2	1	6	0	13	13	7	9	42	1	0	1	0	0	1	0
100	1	0	0	0	1	0	0	0	1	0	1	0	13	9	5	1	28	1	0	3	1	0	4	0
110	0	0	0	0	0	0	0	0	1	0	1	0	1	4	0	2	7	0	0	3	0	0	3	0
120	1	0	0	0	1	0	0	0	0	0	0	0	1	1	0	2	4	0	0	6	0	1	7	0
130	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	13	0	0	13	0
140	0	0	0	0	0	0	0	0	0	0	0	0	7	1	0	0	8	0	0	0	0	1	1	0
150	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	8	0	0	20	0	1	21	0
160	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	2	5	0	0	15	2	0	17	0
170	0	0	0	0	0	0	0	0	0	0	0	0	11	0	1	1	13	0	0	13	1	1	15	0
180	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	1	10	0	0	3	0	0	3	0
190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
200	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0
210	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
390	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	5	1	4	2	12	0	8	3	5	1	17	0	86	54	20	19	179	7	2	77	5	4	88	3

GOLDEN SHINER

LINTV	GL JAN 9 DAY	DSK	NGI	DWN	(TOT	I/24)	GL JAN 17 DAY	DSK	NGI	DWN	(TOT	I/24)
80	1	0	0	0	1	0	0	0	0	0	0	0
110	2	0	0	0	2	0	0	1	0	0	1	0
TOTAL	3	0	0	0	3	0	0	1	0	0	1	0

LINTV	GL MAR 14 DAY	DSK	NGI	DWN	(TOT	I/24)	GL MAR 21 DAY	DSK	NGI	DWN	(TOT	I/24)
100	0	0	0	0	0	0	0	0	0	1	1	0
110	1	0	1	0	2	0	1	0	0	0	1	0
120	0	0	0	0	0	0	0	1	0	0	1	0
130	1	0	0	0	1	0	0	0	1	0	1	0
TOTAL	2	0	1	0	3	0	1	1	1	1	4	0

LINTV	GL APR 7 DAY	DSK	NGI	DWN	(TOT	I/24)	GL APR 11 DAY	DSK	NGI	DWN	(TOT	I/24)
80	0	1	0	0	1	0	0	0	1	0	1	0
90	1	1	0	0	2	0	0	0	0	0	0	0
100	0	2	1	1	4	0	1	0	0	0	1	0
110	0	0	1	0	1	0	0	0	2	0	2	0
120	0	1	0	0	1	0	0	0	1	0	1	0
130	0	0	1	0	1	0	0	0	1	0	1	0
TOTAL	1	5	3	1	10	0	1	0	5	0	6	0

LINTV	GL DEC 17 DAY	DSK	NGI	DWN	(TOT	I/24)
100	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

Appendix 8. Continued.

GOLDFISH

GF JAN 17

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
140	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

GF MAR 29

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	0	0	1	1	0
TOTAL	0	0	0	1	1	0

GF APR 11

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
90	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

GF MAY 24

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
230	0	0	0	1	1	0
TOTAL	0	0	0	1	1	0

LAKE TROUT

LT MAY 30

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
140	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

LT SEP 5

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
660	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

LT OCT 24

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
640	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

LT NOV 26

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
690	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

LT DEC 10

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
820	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

Appendix 8. Continued.

LARGEMOUTH BASS

	LB JAN 3						LB JAN 9						LB JAN 17						LB JAN 22					
LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)
60	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
70	2	0	0	0	2	0	3	0	0	0	3	0	1	4	0	0	5	0	0	0	0	0	0	0
80	1	1	1	0	3	0	1	0	1	0	2	0	1	3	0	1	5	0	0	0	0	0	0	0
90	1	0	0	0	1	0	0	2	2	0	4	0	0	0	0	0	0	0	0	0	1	0	1	0
100	0	0	0	0	0	0	1	1	0	0	2	0	0	1	0	0	1	0	0	0	0	0	0	0
110	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
190	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
260	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
TOTAL	4	1	1	0	6	0	6	3	3	0	12	0	2	9	1	1	13	0	1	0	1	1	3	0

	LB JAN 29					
LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
60	0	0	0	0	0	0
70	0	1	0	0	1	0
80	1	0	0	0	1	0
90	0	0	0	0	0	0
100	0	0	0	0	0	0
110	0	0	0	0	0	0
130	0	0	0	0	0	0
190	0	0	0	0	0	0
260	0	0	0	0	0	0
TOTAL	1	1	0	0	2	0

	LB FEB 5						LB FEB 12						LB FEB 28					
LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	CSK	NGT	DWN	(TOT	T/24)
70	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	0	1	0
TOTAL	0	1	0	0	1	0	1	0	0	0	1	0	1	0	0	0	1	0

	LB MAR 14					
LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	1	0	0	0	1	0
80	0	0	0	1	1	0
90	1	0	0	0	1	0
TOTAL	2	0	0	1	3	0

	LB APR 7						LB APR 11					
LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)
80	0	1	0	0	1	0	0	0	1	0	1	0
90	1	1	0	0	2	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	1	1	0
TOTAL	1	2	0	0	3	0	0	0	1	1	2	0

	LB AUG 7						LB AUG 14						LB AUG 21						LB AUG 29					
LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)	DAY	DSK	NGT	DWN	(TOT	T/24)
60	1	0	0	0	1	0	2	0	0	0	2	0	0	0	0	0	0	0	0	1	0	0	1	0
70	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
TOTAL	2	0	0	0	2	0	2	0	0	0	2	0	0	1	0	0	1	0	0	1	0	0	1	0

Appendix 8. Continued.

LB OCT 3

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
50	0	0	0	0	0	0
60	0	0	0	0	0	0
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	1	0	0	0	1	0
100	0	0	0	0	0	0
110	0	0	0	0	0	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
160	0	0	1	0	1	0
170	0	0	0	0	0	0
TOTAL	1	0	1	0	2	0

LB OCT 18

LINIV	ONE 24-HR SAMPLE	(TOT	I/24)
50	0	0	0
60	1	1	0
70	1	1	0
80	1	1	0
90	2	2	0
100	2	2	0
110	0	0	0
120	0	0	0
130	0	0	0
160	0	0	0
170	0	0	0
TOTAL	7	7	0

LB OCT 24

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
50	0	0	0	1	1	0
60	2	2	0	0	4	0
70	5	1	2	3	11	0
80	15	5	4	7	31	1
90	21	7	2	6	36	1
100	6	3	0	0	9	0
110	5	3	0	1	9	0
120	1	0	0	0	1	0
130	0	1	0	0	1	0
160	0	0	0	0	0	0
170	1	0	0	0	1	0
TOTAL	56	22	8	18	104	4

LB OCT 30

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
50	0	0	0	0	0	0
60	1	0	0	0	1	0
70	1	1	0	0	2	0
80	0	0	0	0	0	0
90	0	0	0	0	0	0
100	0	0	0	0	0	0
110	0	0	0	0	0	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
160	0	0	0	0	0	0
170	0	0	0	0	0	0
TOTAL	2	1	0	0	3	0

LB NOV 7

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
50	0	0	0	0	0	0
60	0	0	0	0	0	0
70	0	0	0	1	1	0
80	0	0	1	0	1	0
90	0	0	0	0	0	0
TOTAL	0	0	1	1	2	0

LB NOV 14

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
50	0	0	0	0	0	0
60	0	0	0	0	0	0
70	1	0	0	0	1	0
80	0	0	0	0	0	0
90	0	0	0	0	0	0
TOTAL	1	0	0	0	1	0

LB NOV 20

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
50	0	0	0	0	0	0
60	0	0	0	0	0	0
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

LB NOV 26

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
50	0	1	0	0	1	0
60	0	0	0	1	1	0
70	0	1	0	0	1	0
80	0	0	0	0	0	0
90	1	1	3	1	6	0
TOTAL	1	3	3	2	9	0

LB DEC 4

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	2	0	0	0	2	0
70	0	0	0	0	0	0
80	0	1	0	0	1	0
100	1	0	0	0	1	0
TOTAL	3	1	0	0	4	0

LB DEC 17

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	1	0	0	0	1	0
70	0	0	1	1	2	0
80	0	0	0	0	0	0
100	1	0	0	0	1	0
TOTAL	2	0	1	1	4	0

LOGPERCH

LP OCT 24

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
90	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

LONGNOSE SUCKER

LS AUG 21

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
90	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

MOTTLED SCULPIN

MS FEB 12

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
70	1	0	0	?	1	0
TOTAL	1	0	0	0	1	0

MS MAR 21

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
90	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

MS APR 11

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
90	0	0	1	0	1	0
100	0	0	1	0	1	0
TOTAL	0	0	2	0	2	0

MS APR 25

DAY	DSK	NGT	DWN	(TOT	I/24)
0	1	0	0	1	0
0	0	0	0	0	0
0	1	0	0	1	0

MS NOV 14

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	C	1	0	1	0
TOTAL	0	0	1	0	1	0

NINESPINE STICKLEBACK

NS MAR 28

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
70	0	2	C	0	2	0
TOTAL	0	2	0	0	2	0

NS APR 11

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
70	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

NS MAY 2

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
70	0	1	0	0	1	0
TOTAL	0	1	0	0	1	C

NS MAY 23

DAY	DSK	NGT	DWN	(TOT	I/24)
0	1	0	2	3	0
0	1	0	2	3	0

NS JUN 15

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
70	0	C	0	1	1	0
80	0	0	0	0	0	0
TOTAL	0	0	0	1	1	0

NS JUN 19

DAY	DSK	NGT	DWN	(TOT	I/24)
0	0	0	0	0	0
1	0	0	0	1	0
1	0	0	0	1	0

NS JUL 4

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
70	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

NS JUL 19

DAY	DSK	NGT	DWN	(TOT	I/24)
0	0	1	0	1	0
0	0	1	0	1	0

NS OCT 18

LINTV	ONE 24-HR SAMPLE	(TOT	I/24)
50	1	1	0
TOTAL	1	1	0

NS DEC 10

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	1	C	C	0	1	0
TOTAL	1	0	0	0	1	0

NORTHERN PIKE

NP JAN 3

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
250	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

NP MAR 21

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
170	0	0	1	0	1	0
180	0	0	1	0	1	0
190	0	1	2	0	3	0
200	0	0	1	0	1	0
220	0	0	0	1	1	0
240	0	1	0	0	1	0
250	1	0	0	0	1	0
270	0	0	1	0	1	0
280	1	0	0	0	1	0
360	0	0	0	0	0	0
TOTAL	2	2	6	1	11	0

NP MAR 28

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
170	0	0	0	0	0	0
180	0	0	0	0	0	0
190	0	0	0	0	0	0
200	0	0	0	0	0	0
220	0	0	0	0	0	0
240	0	0	0	0	0	0
250	0	0	0	0	0	0
270	0	0	0	0	0	0
280	0	0	0	0	0	0
360	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

NP APR 7

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
210	0	0	0	0	0	0
220	0	0	0	0	0	0
280	0	0	1	0	1	0
290	0	1	0	0	1	0
TOTAL	0	1	1	0	2	0

NP APR 11

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
210	1	0	0	0	1	0
220	0	0	1	0	1	0
280	0	0	0	0	0	0
290	0	0	0	0	0	0
TOTAL	1	0	1	0	2	0

NP APR 16

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
210	1	0	0	0	1	0
220	0	0	0	0	0	0
280	0	0	0	0	0	0
290	1	0	0	0	1	0
TOTAL	2	0	0	0	2	0

NP JUN 15

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
100	0	0	0	1	1	0
TOTAL	0	0	0	1	1	0

NP JUL 10

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
110	0	0	0	0	0	0
120	0	0	0	0	0	0
240	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

NP JUL 19

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
110	1	0	0	0	1	0
120	1	0	0	0	1	0
240	0	0	0	0	0	0
TOTAL	2	0	0	0	2	0

NP JUL 25

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
110	1	0	0	0	1	0
120	0	0	0	0	0	0
240	0	0	0	0	0	0
TOTAL	1	0	0	0	1	0

NP DEC 10

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
130	0	0	0	0	0	0
140	0	0	0	0	0	0
150	0	0	0	0	0	0
160	0	0	0	0	0	0
170	0	0	0	0	0	0
200	1	0	0	0	1	0
210	0	0	0	0	0	0
240	0	0	0	0	0	0
TOTAL	1	0	0	0	1	0

NP DEC 17

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
130	0	0	0	0	0	0
140	0	0	0	0	0	0
150	0	0	0	0	0	0
160	0	0	0	0	0	0
170	1	0	0	0	1	0
200	0	0	0	0	0	0
210	1	0	0	0	1	0
240	0	0	0	0	0	0
TOTAL	2	0	0	0	2	0

NP DEC 27

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
130	0	1	1	1	3	0
140	0	1	0	0	1	0
150	0	0	0	1	1	0
160	0	1	0	1	2	0
170	0	1	1	0	2	0
200	0	0	0	0	0	0
210	0	1	0	0	1	0
240	0	0	1	0	1	0
TOTAL	0	5	3	3	11	0

Appendix 8. Continued.

PUMPKINSEED

PS JAN 29

LINTV	DAY	DSK	NGT	DWN	TOT	T/24
140	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

PS APR 7 / PS APR 11 / PS APR 25

LINTV	DAY	DSK	NGT	DWN	TOT	T/24	DAY	DSK	NGT	DWN	TOT	T/24	DAY	DSK	NGT	DWN	TOT	T/24
50	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
70	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
100	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
150	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	2	0	2	0	0	0	2	0	2	0	0	1	0	0	1	0

PS OCT 18

LINTV	ONE 24-HR SAMPLE	TOT	T/24
70	1	1	0
TOTAL	1	1	0

PS NOV 7

LINTV	DAY	DSK	NGT	DWN	TOT	T/24
130	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

QUILLBACK

QL DEC 17 / QL DEC 27

LINTV	DAY	DSK	NGT	DWN	TOT	T/24	DAY	DSK	NGT	DWN	TOT	T/24
160	0	0	0	0	0	0	0	1	0	0	1	0
180	0	0	0	0	0	0	0	0	1	0	1	0
190	1	0	0	0	1	0	0	0	0	0	0	0
200	1	0	0	0	1	0	0	0	0	0	0	0
230	0	1	0	0	1	0	0	0	0	0	0	0
TOTAL	2	1	0	0	3	0	0	1	1	0	2	0

RAINBOW SMELT

SM JAN 3

LINTV	DAY	DSK	NGT	DWN	TOT	T/24
80	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

SM APR 11 / SM APR 16 / SM APR 25

LINTV	DAY	DSK	NGT	DWN	TOT	T/24	DAY	DSK	NGT	DWN	TOT	T/24	DAY	DSK	NGT	DWN	TOT	T/24
50	0	0	1	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0
180	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
TOTAL	0	0	1	0	1	0	0	0	1	0	1	0	1	0	0	0	1	0

Appendix 8. Continued.

SM MAY 2

LINTV	DAY	DSK	NGT	DWN	TOT	T/24
50	1	0	0	0	1	0
160	0	1	0	0	1	0
180	0	0	1	0	1	0
TOTAL	1	1	1	0	3	0

SM JUN 8 / SM JUN 15

LINTV	JUN 8 DAY	DSK	NGT	DWN	TOT	T/24	JUN 15 DAY	DSK	NGT	DWN	TOT	T/24
70	0	0	0	0	0	0	0	0	1	0	1	0
170	0	0	0	1	1	0	0	0	0	0	0	0
TOTAL	0	0	0	1	1	0	0	0	1	0	1	0

SM JUL 10 / SM JUL 19

LINTV	JUL 10 DAY	DSK	NGT	DWN	TOT	T/24	JUL 19 DAY	DSK	NGT	DWN	TOT	T/24
100	0	0	0	0	0	0	0	0	1	0	1	0
110	1	0	0	0	1	0	0	0	0	0	0	0
150	0	0	0	0	0	0	0	1	0	0	1	0
TOTAL	1	0	0	0	1	0	0	1	1	0	2	0

SM AUG 1 / SM AUG 7

LINTV	AUG 1 DAY	DSK	NGT	DWN	TOT	T/24	AUG 7 DAY	DSK	NGT	DWN	TOT	T/24
30	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	3	0	3	0
50	0	0	0	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	0	0	0	0	0	0	0	0	0
90	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	1	1	0	0	0	0	0	0	0
110	0	0	1	0	1	0	0	0	0	0	0	0
120	0	0	0	0	0	0	0	0	0	0	0	0
130	0	0	0	0	0	0	0	0	0	0	0	0
150	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	1	1	2	0	0	0	3	0	3	0

SM AUG 14 / SM AUG 21

LINTV	AUG 14 DAY	DSK	NGT	DWN	TOT	T/24	AUG 21 DAY	DSK	NGT	DWN	TOT	T/24
30	7	24	15	3	49	2	6	0	1	3	10	0
40	5	17	0	4	26	1	3	0	5	1	9	0
50	0	0	0	0	0	0	0	0	2	0	2	0
70	0	0	0	0	0	0	0	0	0	1	1	0
80	0	1	0	0	1	0	0	1	0	0	1	0
90	0	0	0	0	0	0	0	1	1	0	2	0
100	0	3	0	0	3	0	1	1	1	0	3	0
110	0	0	0	0	0	0	0	0	1	0	1	0
120	0	1	1	0	2	0	0	0	0	0	0	0
130	0	0	0	1	1	0	0	0	0	0	0	0
150	0	0	0	1	1	0	0	0	0	0	0	0
TOTAL	12	46	16	9	83	3	10	3	11	5	29	1

SM AUG 29

LINTV	DAY	DSK	NGT	DWN	TOT	T/24
20	0	2	0	0	2	0
30	5	4	1	4	14	0
40	1	0	0	8	9	0
50	0	0	0	3	3	0
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	0	1	1	0	2	0
100	0	1	0	0	1	0
110	0	0	0	0	0	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
150	0	0	0	0	0	0
TOTAL	6	8	2	15	31	1

SM SEP 12 / SM SEP 18 / SM SEP 26

LINTV	SEP 12 ONE 24-HR SAMPLE	TOT	T/24	SEP 18 DAY	DSK	NGT	DWN	TOT	T/24	SEP 26 DAY	DSK	NGT	DWN	TOT	T/24
30	5	5	0	2	0	0	2	4	0	0	0	0	0	0	0
40	8	8	0	6	0	1	2	9	0	1	0	1	0	2	0
50	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0
60	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
80	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
90	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
110	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0
130	0	0	0	2	0	1	0	3	0	0	0	0	0	0	0
140	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
150	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
160	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
TOTAL	16	16	0	13	0	6	4	23	0	1	0	1	0	2	0

Appendix 8. Continued.

SM OCT 3

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
30	0	0	0	0	0	0
40	0	0	0	1	1	0
50	0	0	0	0	0	0
50	0	0	0	0	0	0
120	0	0	0	0	0	0
150	0	0	0	0	0	0
160	0	0	0	0	0	0
200	0	0	0	0	0	0
TOTAL	0	0	0	1	1	0

SM OCT 8

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
30	0	0	1	0	1	0
40	0	1	0	0	1	0
50	1	1	0	2	4	0
50	0	0	0	0	0	0
120	0	0	0	0	0	0
150	0	0	1	0	1	0
160	0	0	0	0	0	0
200	0	0	0	0	0	0
TOTAL	1	2	2	2	7	0

SM OCT 18

LINTV	ONE 24-HR SAMPLE	(TOT	I/24)
30	1	1	0
40	13	13	0
50	10	10	0
50	0	0	0
120	1	1	0
150	0	0	0
160	1	1	0
200	1	1	0
TOTAL	27	27	1

SM OCT 24

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
30	0	0	0	0	0	0
40	2	2	2	0	6	0
50	9	11	4	1	25	1
50	2	2	2	0	6	0
120	0	0	0	0	0	0
150	0	0	0	0	0	0
160	0	0	0	0	0	0
200	0	0	0	0	0	0
TOTAL	13	15	8	1	37	1

SM NOV 7

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
40	1	0	0	0	1	0
50	0	2	1	1	4	0
60	0	4	3	3	10	0
70	0	1	0	0	1	0
90	1	0	0	0	1	0
100	0	0	1	0	1	0
110	0	0	0	0	0	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
140	0	0	0	0	0	0
TOTAL	2	7	5	4	18	0

SM NOV 14

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
40	0	0	0	0	0	0
50	0	0	0	0	0	0
60	1	1	2	1	5	0
70	0	1	0	0	1	0
90	0	0	0	0	0	0
100	0	0	0	0	0	0
110	0	0	0	0	0	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
140	0	0	0	0	0	0
TOTAL	1	2	2	1	6	0

SM NOV 20

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
40	0	0	0	0	0	0
50	1	1	0	0	2	0
60	1	3	0	1	5	0
70	0	0	0	0	0	0
90	0	0	0	0	0	0
100	0	0	0	0	0	0
110	0	0	0	0	0	0
120	1	0	1	0	2	0
130	0	0	0	0	0	0
140	0	0	0	0	0	0
TOTAL	3	4	1	1	9	0

SM NOV 26

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
40	1	0	0	0	1	0
50	4	2	3	0	9	0
60	3	9	6	1	19	0
70	2	6	2	2	12	0
90	0	0	0	0	0	0
100	0	0	0	0	0	0
110	1	0	0	0	1	0
120	0	0	0	0	0	0
130	1	0	0	0	1	0
140	0	1	1	0	2	0
TOTAL	12	18	12	3	45	1

SM OCT 30

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
30	1	0	0	0	1	0
40	3	0	0	0	3	0
50	1	2	0	0	3	0
60	0	0	0	1	1	0
120	0	0	1	0	1	0
150	0	0	0	0	0	0
160	0	0	0	0	0	0
200	0	0	0	0	0	0
TOTAL	5	2	1	1	9	0

SM DEC 4

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
50	0	0	0	0	0	0
60	0	0	0	0	0	0
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	0	0	0	0	0	0
150	0	1	0	0	1	0
160	0	1	1	0	2	0
TOTAL	0	2	1	0	3	0

SM DEC 10

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
50	0	0	1	0	1	0
60	2	0	1	1	4	0
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	0	0	0	0	0	0
150	0	0	0	0	0	0
160	0	0	0	0	0	0
TOTAL	2	0	2	1	5	0

SM DEC 17

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
50	0	0	0	0	0	0
60	2	0	0	1	3	0
70	3	0	0	0	3	0
80	1	0	0	0	1	0
90	0	0	0	1	1	0
150	0	0	0	0	0	0
160	0	0	0	0	0	0
TOTAL	6	0	0	2	8	0

SM DEC 27

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
50	0	0	0	0	0	0
60	0	0	0	0	0	0
70	0	1	0	0	1	0
80	0	0	0	0	0	0
90	0	0	0	0	0	0
150	0	0	0	0	0	0
160	0	0	0	0	0	0
TOTAL	0	1	0	0	1	0

Appendix 8. Continued.

RAINBOW TROUT

RT DEC 18

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
700	0	0	0	1	1	0
TOTAL	0	0	0	1	1	0

ROCK BASS

RB FEB 20

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
140	0	0	0	1	1	0
TOTAL	0	0	0	1	1	0

RB JUN 7

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
160	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

RB AUG 21

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
180	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

RB NOV 7

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
50	0	0	1	0	1	0
160	0	0	0	0	0	0
TOTAL	0	0	1	0	1	0

RB NOV 14

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
50	0	0	0	0	0	0
160	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

SEA LAMPREY

SL MAR 28

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
300	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

SL NOV 20

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
510	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

SHORTHEAD REDHORSE

SR JAN 17

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
220	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

Appendix 8. Continued.

SLIMY SCULPIN

SS JAN 9

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	0	0	0	0	0
80	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

SS JAN 23

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	0	0	1	1	0
80	0	0	0	0	0	0
TOTAL	0	0	0	1	1	0

SS FEB 19

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
110	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

SS MAR 5

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
90	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

SS APR 11

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	0	3	0	3	0
80	0	1	1	1	3	0
110	0	0	1	0	1	0
TOTAL	0	1	5	1	7	0

SS APR 16

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	1	0	0	1	2	0
80	0	0	1	0	1	0
110	0	0	0	0	0	0
TOTAL	1	0	1	1	3	0

SS NOV 26

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
60	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

SMALLMOUTH BASS

SB JUN 28

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
180	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

SB OCT 31

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
150	0	0	0	1	1	0
TOTAL	0	0	0	1	1	0

SPOTTAIL SHINER

SP JAN 3

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	1	0	0	0	1	0
80	1	0	0	0	1	0
90	0	2	0	0	2	0
100	0	0	1	0	1	0
110	0	0	0	0	0	0
120	0	0	1	1	2	0
130	1	0	0	0	1	0
TOTAL	3	2	2	1	8	0

SP JAN 9

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	0	1	0	1	0
80	0	0	0	0	0	0
90	0	2	0	0	2	0
100	0	1	0	0	1	0
110	0	0	0	0	0	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
TOTAL	0	3	1	0	4	0

SP JAN 17

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	0	0	0	0	0
80	1	0	0	0	1	0
90	1	1	1	0	3	0
100	1	0	0	0	1	0
110	0	0	0	1	1	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
TOTAL	3	1	1	1	6	0

SP JAN 22

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	1	0	0	1	0
80	1	1	0	1	3	0
90	2	4	3	1	10	0
100	0	5	1	2	8	0
110	0	1	0	0	1	0
120	0	0	0	0	0	0
130	0	0	1	0	1	0
TOTAL	3	12	5	4	24	1

SP JAN 29

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
70	0	0	0	0	0	0
80	1	1	2	0	4	0
90	0	2	1	0	3	0
100	1	0	1	0	2	0
110	1	0	1	0	2	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
TOTAL	3	3	5	0	11	0

SP FEB 5

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	1	1	1	1	4	0
90	1	4	0	0	5	0
100	1	0	0	0	1	0
110	2	1	0	0	3	0
TOTAL	5	6	1	1	13	0

SP FEB 12

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	1	0	0	1	0
90	1	0	0	1	2	0
100	1	1	0	0	2	0
110	0	0	0	0	0	0
TOTAL	2	2	0	1	5	0

SP FEB 19

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	0	0	0	0	0
90	0	2	7	0	9	0
100	2	3	2	0	7	0
110	1	0	0	0	1	0
TOTAL	3	5	9	0	17	0

SP FEB 28

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	0	0	0	0	0
90	0	1	0	0	1	0
100	0	1	0	0	1	0
110	1	0	0	0	1	0
TOTAL	1	2	0	0	3	0

SP MAR 5

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	0	0	0	0	0	0
70	0	0	0	0	0	0
80	1	0	0	0	1	0
90	9	8	4	2	23	0
100	15	7	5	4	31	1
110	3	1	3	1	8	0
120	1	1	0	2	4	0
130	4	1	0	0	5	0
140	0	0	0	0	0	0
TOTAL	33	18	12	9	72	3

SP MAR 14

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	0	0	0	0	0	0
70	0	0	0	0	0	0
80	1	0	0	0	1	0
90	2	0	2	0	4	0
100	1	1	0	0	2	0
110	0	0	0	0	0	0
120	2	0	4	0	6	0
130	0	1	1	0	2	0
140	0	0	0	0	0	0
TOTAL	6	2	7	0	15	0

SP MAR 21

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	0	0	0	0	0	0
70	0	0	0	0	0	0
80	0	1	0	0	1	0
90	0	2	0	0	2	0
100	0	0	0	1	1	0
110	0	1	2	0	3	0
120	0	0	0	0	0	0
130	0	0	2	0	2	0
140	0	0	0	0	0	0
TOTAL	0	4	4	1	9	0

SP MAR 28

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	0	1	0	0	1	0
70	0	1	1	0	2	0
80	0	3	9	2	14	0
90	0	4	12	4	20	0
100	3	4	13	3	23	0
110	1	4	9	4	18	0
120	0	3	13	4	20	0
130	0	0	5	1	6	0
140	1	0	2	0	3	0
TOTAL	5	20	64	18	107	4

SP APR 7

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	0	0	0	0	0	0
80	0	1	1	0	2	0
90	0	1	0	0	1	0
100	0	1	3	0	4	0
110	0	2	0	0	2	0
120	0	3	1	0	4	0
130	0	1	0	0	1	0
140	0	1	0	0	1	0
TOTAL	0	10	5	0	15	0

SP APR 11

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	0	0	0	1	1	0
80	0	0	0	2	2	0
90	1	2	12	1	16	0
100	0	0	9	2	11	0
110	1	0	4	4	9	0
120	0	2	3	6	11	0
130	2	0	1	3	6	0
140	0	0	0	1	1	0
TOTAL	4	4	29	20	57	2

SP APR 16

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	0	0	0	0	0	0
80	1	1	2	1	5	0
90	1	2	1	0	4	0
100	4	1	0	0	5	0
110	1	0	0	0	1	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
140	0	0	0	0	0	0
TOTAL	7	4	3	1	15	0

SP APR 25

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	0	0	0	0	0	0
80	0	0	0	0	0	0
90	0	0	0	0	0	0
100	1	1	1	0	3	0
110	0	0	1	0	1	0
120	0	1	0	0	1	0
130	0	0	1	0	1	0
140	0	0	0	0	0	0
TOTAL	1	2	3	0	6	0

Appendix 8. Continued.

SP MAY 2

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	1	0	0	1	0
80	0	0	1	0	1	0
90	1	1	1	0	3	0
100	2	0	0	0	2	0
110	1	0	0	0	1	0
120	0	0	0	1	1	0
130	0	0	1	1	2	0
TOTAL	4	2	3	2	11	0

SP MAY 17

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	0	0	0	0	0
80	0	0	0	1	1	0
90	0	1	0	0	1	0
100	0	0	0	1	1	0
110	0	1	0	0	1	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
TOTAL	0	2	0	2	4	0

SP MAY 23

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	0	0	0	0	0
80	0	0	0	1	1	0
90	0	0	0	1	1	0
100	3	0	0	1	4	0
110	0	0	0	4	4	0
120	0	0	1	1	2	0
130	0	1	0	1	2	0
TOTAL	3	1	1	9	14	0

SP MAY 30

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	0	0	0	0	0	0
100	0	0	3	0	3	0
110	0	0	0	0	0	0
120	1	0	3	0	4	0
130	0	0	0	0	0	0
TOTAL	1	0	6	0	7	0

SP JUN 7

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
90	0	0	0	1	1	0
100	1	0	0	0	1	0
110	0	0	0	0	0	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
140	0	0	0	0	0	0
TOTAL	1	0	0	1	2	0

SP JUN 14

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
90	0	0	0	0	0	0
100	0	0	1	0	1	0
110	0	0	1	0	1	0
120	0	0	1	1	2	0
130	1	0	1	3	5	0
140	0	0	0	0	0	0
TOTAL	1	0	4	4	9	0

SP JUN 19

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
90	2	0	0	0	2	0
100	0	0	0	1	1	0
110	0	1	0	3	4	0
120	1	1	0	0	2	0
130	0	0	0	1	1	0
140	0	0	0	0	0	0
TOTAL	3	2	0	5	10	0

SP JUN 28

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
90	0	0	0	1	1	0
100	0	0	0	2	2	0
110	0	2	0	0	2	0
120	0	0	1	6	7	0
130	0	1	1	2	4	0
140	0	0	0	1	1	0
TOTAL	0	3	2	12	17	0

SP JUL 4

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	1	0	0	0	1	0
80	0	0	0	0	0	0
90	0	1	0	0	1	0
100	0	1	1	1	3	0
110	1	0	1	0	2	0
120	0	0	2	2	4	0
130	0	0	2	0	2	0
TOTAL	2	2	6	3	13	0

SP JUL 10

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	5	7	10	2	24	1
100	1	6	3	3	13	0
110	2	1	3	4	10	0
120	1	1	0	3	5	0
130	0	1	1	1	3	0
TOTAL	9	16	17	13	55	2

SP JUL 19

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	14	7	5	2	28	1
100	19	10	11	4	44	1
110	9	3	7	2	21	0
120	7	1	4	0	12	0
130	2	0	1	0	3	0
TOTAL	51	21	28	8	108	4

SP JUL 25

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	0	0	0	0	0
80	0	0	2	0	2	0
90	0	2	2	1	5	0
100	0	2	1	0	3	0
110	0	0	1	0	1	0
120	1	1	0	0	2	0
130	0	1	0	0	1	0
TOTAL	1	6	6	1	14	0

SP AUG 1

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
30	0	0	0	0	0	0
70	0	0	1	0	1	0
80	1	0	0	0	1	0
90	2	0	0	0	2	0
100	2	0	1	0	3	0
110	1	0	0	0	1	0
120	0	0	1	1	2	0
130	0	0	0	0	0	0
140	0	0	0	0	0	0
TOTAL	6	0	3	1	10	0

SP AUG 7

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
30	0	0	0	0	0	0
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	0	1	0	1	2	0
100	1	0	0	1	2	0
110	1	1	0	0	2	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
140	0	0	0	0	0	0
TOTAL	2	2	0	2	6	0

SP AUG 14

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
30	0	0	1	0	1	0
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	1	1	0	1	3	0
100	0	3	4	0	7	0
110	0	0	0	0	0	0
120	0	1	0	0	1	0
130	1	0	0	0	1	0
140	1	0	0	0	1	0
TOTAL	3	5	5	1	14	0

SP AUG 21

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
30	0	0	0	0	0	0
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	1	1	0	0	2	0
100	1	0	0	0	1	0
110	0	0	0	0	0	0
120	1	0	0	0	1	0
130	0	0	0	0	0	0
140	0	0	0	0	0	0
TOTAL	3	1	0	0	4	0

Appendix 8. Continued.

SP AUG 30

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
30	0	0	0	0	0	0
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	0	0	0	1	1	0
100	0	0	0	2	2	0
110	0	0	0	1	1	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
140	0	0	0	0	0	0
TOTAL	0	0	0	4	4	0

SP SEP 12

LINIV	ONE 24-HR SAMPLE	(TOT	I/24)
100	2	2	0
110	2	2	0
TOTAL	4	4	0

SP SEP 18

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
100	0	0	0	1	1	0
110	0	1	0	0	1	0
TOTAL	0	1	0	1	2	0

SP SEP 26

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
100	0	0	1	1	2	0
110	0	0	0	0	0	0
TOTAL	0	0	1	1	2	0

SP OCT 2

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	0	0	0	0	0
90	1	0	0	0	1	0
100	0	1	0	0	1	0
110	0	0	1	0	1	0
120	0	1	0	0	1	0
130	0	0	0	0	0	0
TOTAL	1	2	1	0	4	0

SP OCT 18

LINIV	ONE 24-HR SAMPLE	(TOT	I/24)
80	0	0	0
90	0	0	0
100	2	2	0
110	2	2	0
120	0	0	0
130	1	1	0
TOTAL	5	5	0

SP OCT 24

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	0	0	0	0	0
90	0	0	1	0	1	0
100	0	2	0	0	2	0
110	0	1	0	0	1	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
TOTAL	0	3	1	0	4	0

SP OCT 30

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	1	0	0	1	0
90	0	0	0	0	0	0
100	1	0	0	0	1	0
110	0	0	0	1	1	0
120	1	0	2	0	3	0
130	0	0	0	0	0	0
TOTAL	2	1	2	1	6	0

SP NOV 7

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	0	0	0	0	0
90	0	0	0	0	0	0
100	0	0	0	0	0	0
110	1	0	0	0	1	0
120	0	0	1	1	2	0
130	0	0	0	0	0	0
TOTAL	1	0	1	1	3	0

SP NOV 14

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	0	1	0	1	0
90	0	1	0	0	1	0
100	1	1	0	0	2	0
110	0	0	0	0	0	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
TOTAL	1	2	1	0	4	0

SP NOV 20

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	0	0	0	0	0
90	1	0	0	0	1	0
100	1	0	0	0	1	0
110	0	0	0	0	0	0
120	0	2	1	1	4	0
130	0	0	0	0	0	0
TOTAL	2	2	1	1	6	0

SP NOV 26

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	0	0	0	0	0
90	1	4	0	0	5	0
100	2	6	5	3	16	0
110	8	14	9	3	34	1
120	0	1	4	0	5	0
130	0	4	2	1	7	0
TOTAL	11	29	20	7	67	2

SP DEC 4

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
40	0	0	0	0	0	0
70	0	0	1	0	1	0
80	0	0	1	0	1	0
90	0	0	0	0	0	0
100	1	0	0	0	1	0
110	0	1	0	0	1	0
120	0	0	0	0	0	0
140	1	0	0	0	1	0
TOTAL	2	1	2	0	5	0

SP DEC 10

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
40	0	0	0	0	0	0
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	0	0	0	0	0	0
100	1	1	0	0	2	0
110	1	1	1	0	3	0
120	1	0	0	0	1	0
140	1	0	0	0	1	0
TOTAL	4	2	1	0	7	0

SP DEC 17

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
40	1	0	0	0	1	0
70	2	0	0	1	3	0
80	0	1	1	0	2	0
90	1	0	0	0	1	0
100	2	0	0	0	2	0
110	1	0	0	0	1	0
120	0	1	0	0	1	0
140	0	0	0	0	0	0
TOTAL	7	2	1	1	11	0

SP DEC 27

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
40	0	0	0	0	0	0
70	0	0	0	0	0	0
80	0	1	0	1	2	0
90	0	0	0	0	0	0
100	0	1	0	0	1	0
110	0	0	0	0	0	0
120	0	1	0	0	1	0
140	0	0	0	0	0	0
TOTAL	0	3	0	1	4	0

Appendix 8. Continued.

TADPOLE MADTOM

MT JUN 28

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
90	0	0	0	1	1	0
TOTAL	0	0	0	1	1	0

MT JUL 19

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
70	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

MT AUG 8

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
50	0	0	0	0	0	0
60	0	0	0	1	1	0
80	0	0	0	0	0	0
TOTAL	0	0	0	1	1	0

MT AUG 21

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
50	1	0	0	0	1	0
60	0	0	0	0	0	0
80	1	0	0	0	1	0
TOTAL	2	0	0	0	2	0

MT SEP 18

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

MT NOV 14

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

MT DEC 4

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
70	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

TROUT-PERCH

TP JAN 3 / TP JAN 9 / TP JAN 17 / TP JAN 22

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)	DAY	DSK	NGT	DWN	(TOT	I/24)	DAY	DSK	NGT	DWN	(TOT	I/24)	DAY	DSK	NGT	DWN	(TOT	I/24)
	JAN 3						JAN 9						JAN 17						JAN 22					
80	0	0	0	0	0	0	0	0	1	0	1	0	2	0	0	0	2	0	0	0	0	0	0	0
90	0	0	0	0	0	0	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
100	1	0	0	0	1	0	0	0	1	0	1	0	0	0	1	1	2	0	0	1	0	0	1	0
110	0	0	1	0	1	0	0	0	0	0	0	0	2	3	1	0	6	0	2	1	3	0	6	0
120	3	1	0	0	4	0	0	1	0	0	1	0	0	1	0	0	1	0	0	2	1	1	4	0
130	0	0	0	1	1	0	0	0	1	0	1	0	1	2	0	0	3	0	0	1	1	0	2	0
150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0
TOTAL	4	1	1	1	7	0	1	2	3	0	6	0	5	6	2	1	14	0	3	5	5	1	14	0

TP JAN 29

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	0	0	0	0	0
90	0	0	0	0	0	0
100	0	0	0	0	0	0
110	1	0	1	0	2	0
120	1	0	1	0	2	0
130	1	0	0	1	2	0
150	1	0	0	0	1	0
TOTAL	4	0	2	1	7	0

TP FEB 5 / TP FEB 12 / TP FEB 19 / TP FEB 28

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)	DAY	DSK	NGT	DWN	(TOT	I/24)	DAY	DSK	NGT	DWN	(TOT	I/24)	DAY	DSK	NGT	DWN	(TOT	I/24)
	FEB 5						FEB 12						FEB 19						FEB 28					
80	1	0	2	0	3	0	0	0	0	0	0	0	0	0	1	1	2	0	0	0	0	0	0	0
90	0	0	5	0	5	0	0	0	0	0	0	0	0	0	2	0	2	0	0	1	0	0	1	0
100	0	0	1	0	1	0	0	0	0	1	1	0	0	1	1	0	2	0	0	2	0	0	2	0
110	0	1	3	1	5	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	1	0	2	0
120	0	0	1	2	3	0	2	0	1	2	5	0	0	1	0	1	2	0	2	0	0	2	4	0
130	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1	0	5	0	1	1	0	1	3	0
140	1	0	1	0	2	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
TOTAL	2	1	13	3	19	0	3	0	1	3	7	0	2	5	5	2	14	0	4	5	1	3	13	0

Appendix 8. Continued.

LINTV	TP MAR 5 DAY	DSK	NGT	DWN	(TOT	I/24)	TP MAR 14 DAY	DSK	NGT	DWN	(TOT	I/24)	TP MAR 21 DAY	DSK	NGT	DWN	(TOT	I/24)
90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
100	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
110	4	1	2	0	7	0	1	1	0	0	2	0	3	2	1	0	6	0
120	4	5	1	1	11	0	1	1	1	0	3	0	0	1	5	0	6	0
130	1	2	0	0	3	0	0	0	0	0	0	0	0	0	2	0	2	0
140	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	9	10	3	2	24	1	2	2	1	0	5	0	3	3	9	0	15	0

LINTV	TP APR 7 DAY	DSK	NGT	DWN	(TOT	I/24)	TP APR 11 DAY	DSK	NGT	DWN	(TOT	I/24)	TP APR 16 DAY	DSK	NGT	DWN	(TOT	I/24)
100	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0	0	2	0
110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
120	0	0	1	0	1	0	0	1	0	0	1	0	1	1	0	0	2	0
130	0	0	0	0	0	0	1	0	1	1	3	0	0	0	0	0	0	0
TOTAL	0	0	1	0	1	0	1	2	1	1	5	0	2	2	1	0	5	0

LINTV	TP MAY 2 DAY	DSK	NGT	DWN	(TOT	I/24)	TP MAY 18 DAY	DSK	NGT	DWN	(TOT	I/24)
100	0	0	0	0	0	0	0	0	0	1	1	0
120	0	0	1	0	1	0	0	0	0	0	0	0
TOTAL	0	0	1	0	1	0	0	0	0	1	1	0

LINTV	TP JUL 19 DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

LINTV	TP SEP 5 DAY	DSK	NGT	DWN	(TOT	I/24)	TP SEP 19 DAY	DSK	NGT	DWN	(TOT	I/24)	TP SEP 26 DAY	DSK	NGT	DWN	(TOT	I/24)
50	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
100	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
110	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1	0
120	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	2	1	3	0	0	0	0	1	1	0	0	0	1	0	1	0

LINTV	TP OCT 18 ONE 24-HR SAMPLE	(TOT	I/24)	TP OCT 30 DAY	DSK	NGT	DWN	(TOT	I/24)
110	0	0	0	1	3	2	0	6	0
120	1	1	0	1	0	3	0	4	0
130	1	1	0	2	0	2	1	5	0
140	0	0	0	1	0	0	0	1	0
150	0	0	0	1	0	0	0	1	0
TOTAL	2	2	0	6	3	7	1	17	0

Appendix 8. Continued.

TP NOV 7

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
90	0	0	0	0	0	0
100	0	0	0	0	0	0
110	0	2	0	0	2	0
120	0	3	2	0	5	0
130	0	1	1	0	2	0
140	0	0	0	1	1	0
150	0	0	0	1	1	0
160	0	0	0	1	1	0
TOTAL	0	6	3	3	12	0

TP NOV 14

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
90	0	0	0	0	0	0
100	1	0	0	0	1	0
110	3	0	0	0	3	0
120	4	0	0	0	4	0
130	2	0	0	1	3	0
140	1	1	0	0	2	0
150	0	0	0	1	1	0
160	0	0	0	0	0	0
TOTAL	11	1	0	2	14	0

TP NOV 20

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
90	0	0	0	1	1	0
100	0	0	0	0	0	0
110	1	1	4	0	6	0
120	0	4	4	0	8	0
130	0	3	1	1	5	0
140	0	0	2	2	4	0
150	0	0	1	0	1	0
160	0	0	0	0	0	0
TOTAL	1	8	12	4	25	1

TP NOV 26

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
90	0	0	1	0	1	0
100	0	0	0	0	0	0
110	1	0	1	1	3	0
120	1	5	1	0	7	0
130	3	2	1	0	6	0
140	0	1	1	0	2	0
150	0	1	0	0	1	0
160	0	0	0	0	0	0
TOTAL	5	9	5	1	20	0

TP DEC 4

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	0	0	0	0	0
90	0	0	0	0	0	0
100	0	0	0	0	0	0
110	0	0	0	0	0	0
120	0	1	0	0	1	0
130	0	2	0	0	2	0
140	0	0	0	0	0	0
150	0	0	0	0	0	0
TOTAL	0	3	0	0	3	0

TP DEC 10

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	0	0	0	0	0
90	1	0	0	0	1	0
100	0	0	0	0	0	0
110	2	0	0	0	2	0
120	4	0	0	0	4	0
130	0	0	0	0	0	0
140	0	0	0	0	0	0
150	1	0	0	0	1	0
TOTAL	8	0	0	0	8	0

TP DEC 17

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	1	0	0	0	1	0
90	0	0	1	1	2	0
100	0	0	0	1	1	0
110	3	0	0	0	3	0
120	1	2	0	0	3	0
130	3	1	0	0	4	0
140	0	0	0	0	0	0
150	0	0	0	0	0	0
TOTAL	8	3	1	2	14	0

TP DEC 27

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	1	0	0	1	0
90	0	1	0	0	1	0
100	0	0	0	0	0	0
110	0	3	0	0	3	0
120	0	2	0	0	2	0
130	0	0	0	1	1	0
140	0	1	1	0	2	0
150	0	0	0	0	0	0
TOTAL	0	8	1	1	10	0

UNIDENTIFIED COREGONID

XC SEP 6

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
70	0	0	0	1	1	0
TOTAL	0	0	0	1	1	0

XC SEP 12

LINIV	ONE 24-HR SAMPLE	(TOT	I/24)
70	1	1	0
TOTAL	1	1	0

XC OCT 24

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

XC NOV 7

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
50	0	0	0	0	0	0
60	1	0	0	0	1	0
70	0	0	0	0	0	0
80	0	0	1	0	1	0
100	0	0	0	0	0	0
TOTAL	1	0	1	0	2	0

XC NOV 20

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
50	0	0	0	0	0	0
60	0	0	0	0	0	0
70	0	1	0	0	1	0
80	0	0	0	0	0	0
100	0	0	0	0	0	0
TOTAL	0	1	0	0	1	0

XC NOV 26

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
50	0	0	1	0	1	0
60	0	0	0	0	0	0
70	1	0	0	1	2	0
80	0	0	0	0	0	0
100	0	0	1	0	1	0
TOTAL	1	0	2	1	4	0

Appendix 8. Continued.

WALLEYE

WL JAN 3

LINTV	DAY	DSK	NGI	DWN	(TOT	I/24)
230	0	0	0	0	0	0
240	1	0	0	0	1	0
330	0	0	0	0	0	0
TOTAL	1	0	0	0	1	0

WL JAN 17

LINTV	DAY	DSK	NGI	DWN	(TOT	I/24)
230	0	0	0	0	0	0
240	0	0	0	0	0	0
330	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

WL JAN 22

LINTV	DAY	DSK	NGI	DWN	(TOT	I/24)
230	0	0	1	0	1	0
240	0	0	0	0	0	0
330	0	0	0	0	0	0
TOTAL	0	0	1	0	1	0

WL FEB 5

LINTV	DAY	DSK	NGI	DWN	(TOT	I/24)
350	0	0	1	0	1	0
390	0	0	0	0	0	0
TOTAL	0	0	1	0	1	0

WL FEB 12

LINTV	DAY	DSK	NGI	DWN	(TOT	I/24)
350	0	0	0	0	0	0
390	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

WL MAR 14

LINTV	DAY	DSK	NGI	DWN	(TOT	I/24)
300	1	0	0	0	1	0
360	0	1	0	0	1	0
TOTAL	1	1	0	0	2	0

WL DEC 17

LINTV	DAY	DSK	NGI	DWN	(TOT	I/24)
380	1	0	0	0	1	0
390	1	0	0	0	1	0
400	0	1	0	0	1	0
410	1	0	0	0	1	0
TOTAL	3	1	0	0	4	0

WHITE SUCKER

WS FEB 5

LINTV	DAY	DSK	NGI	DWN	(TOT	I/24)
340	0	0	0	0	0	0
430	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

WS FEB 19

LINTV	DAY	DSK	NGI	DWN	(TOT	I/24)
340	0	1	0	0	1	0
430	0	0	0	0	0	0
TOTAL	0	1	0	0	1	0

WS MAR 14

LINTV	DAY	DSK	NGI	DWN	(TOT	I/24)
180	0	0	0	1	1	0
200	0	0	0	0	0	0
220	0	0	0	1	1	0
370	1	1	0	0	2	0
380	0	0	1	0	1	0
410	1	1	0	0	2	0
420	0	0	1	0	1	0
440	0	1	0	0	1	0
450	0	0	0	0	0	0
480	0	0	0	0	0	0
TOTAL	2	3	2	2	9	0

WS MAR 21

LINTV	DAY	DSK	NGI	DWN	(TOT	I/24)
180	0	0	0	0	0	0
200	1	0	0	0	1	0
220	0	0	0	0	0	0
370	1	0	0	0	1	0
380	0	0	0	0	0	0
410	0	0	0	0	0	0
420	0	0	0	0	0	0
440	0	1	0	0	1	0
450	0	0	0	0	0	0
480	0	0	0	1	1	0
TOTAL	2	1	0	1	4	0

WS MAR 28

LINTV	DAY	DSK	NGI	DWN	(TOT	I/24)
180	0	0	0	0	0	0
200	0	0	0	0	0	0
220	0	0	0	0	0	0
370	0	0	0	0	0	0
380	0	0	0	0	0	0
410	1	0	0	0	1	0
420	0	0	0	0	0	0
440	0	0	0	0	0	0
450	0	1	0	0	1	0
480	0	0	0	0	0	0
TOTAL	1	1	0	0	2	0

Appendix 8. Continued.

WS APR 7

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
160	0	0	0	0	0	0
360	0	0	0	0	0	0
390	0	0	0	0	0	0
410	0	0	0	0	0	0
420	0	1	0	0	1	0
430	0	1	0	0	1	0
450	0	1	0	0	1	0
TOTAL	0	3	0	0	3	0

WS APR 11

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
160	0	1	0	0	1	0
360	0	0	0	0	0	0
390	1	0	1	0	2	0
410	0	0	0	0	0	0
420	0	0	0	0	0	0
430	0	0	0	1	1	0
450	0	0	0	0	0	0
TOTAL	1	1	1	1	4	0

WS APR 16

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
160	0	0	0	0	0	0
360	0	1	0	0	1	0
390	0	0	0	0	0	0
410	0	0	0	0	0	0
420	0	0	0	0	0	0
430	0	0	0	0	0	0
450	0	0	0	0	0	0
TOTAL	0	1	0	0	1	0

WS APR 25

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
160	0	0	0	0	0	0
360	0	0	0	0	0	0
390	0	0	0	0	0	0
410	1	0	0	0	1	0
420	1	0	0	0	1	0
430	0	0	0	0	0	0
450	0	0	0	0	0	0
TOTAL	2	0	0	0	2	0

WS MAY 18

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
350	0	0	0	1	1	0
TOTAL	0	0	0	1	1	0

WS DEC 17

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
260	1	0	0	0	1	0
TOTAL	1	0	0	0	1	0

YELLOW BULLHEAD

YB NOV 20

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
150	0	0	1	0	1	0
TOTAL	0	0	1	0	1	0

YELLOW PERCH

YP JAN 4

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	0	0	0	0	0	0
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	0	0	0	0	0	0
110	0	0	0	0	0	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
140	0	0	0	0	0	0
150	0	0	0	1	1	0
160	0	0	0	0	0	0
170	0	0	0	0	0	0
190	0	0	0	0	0	0
200	0	0	0	0	0	0
TOTAL	0	0	0	1	1	0

YP JAN 9

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	0	2	1	0	3	0
70	1	0	2	0	3	0
80	1	4	0	1	6	0
90	1	2	2	0	5	0
110	0	0	0	0	0	0
120	1	0	0	0	1	0
130	1	0	0	0	1	0
140	0	0	0	0	0	0
150	1	0	1	0	2	0
160	0	0	0	0	0	0
170	0	0	0	0	0	0
190	0	0	0	0	0	0
200	0	0	0	0	0	0
TOTAL	6	8	6	1	21	0

YP JAN 17

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	0	1	0	0	1	0
70	0	0	0	0	0	0
80	0	1	1	0	2	0
90	0	2	0	0	2	0
110	0	0	0	1	1	0
120	1	0	0	0	1	0
130	0	0	3	0	3	0
140	0	0	3	0	3	0
150	1	1	0	0	2	0
160	0	1	0	0	1	0
170	1	0	0	0	1	0
190	0	0	1	0	1	0
200	0	0	0	0	0	0
TOTAL	3	6	8	1	18	0

YP JAN 22

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	0	0	0	0	0	0
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	1	2	0	0	3	0
110	0	0	0	0	0	0
120	0	0	0	0	0	0
130	1	0	0	0	1	0
140	0	0	0	0	0	0
150	0	0	0	0	0	0
160	0	0	0	0	0	0
170	0	0	0	0	0	0
190	0	0	0	0	0	0
200	1	0	0	0	1	0
TOTAL	3	2	0	0	5	0

Appendix 8. Continued.

YP JAN 29

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
60	0	0	0	0	0	0
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	0	0	0	0	0	0
110	0	0	0	0	0	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
140	0	0	1	0	1	0
150	0	0	0	0	0	0
160	0	0	0	0	0	0
170	0	0	0	0	0	0
190	0	0	0	0	0	0
200	0	0	0	0	0	0
TOTAL	0	0	1	0	1	0

YP FEB 5

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
70	0	1	1	0	2	0
80	0	1	1	1	3	0
90	0	0	1	0	1	0
110	0	0	1	0	1	0
130	0	0	0	0	0	0
140	0	0	1	0	1	0
150	0	0	0	0	0	0
160	0	0	0	1	1	0
180	1	0	0	0	1	0
TOTAL	1	2	5	2	10	0

YP FEB 12

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
70	0	0	0	0	0	0
80	0	1	0	0	1	0
90	0	0	0	0	0	0
110	0	0	0	0	0	0
130	0	0	0	0	0	0
140	0	0	0	0	0	0
150	0	0	0	0	0	0
160	0	0	0	0	0	0
180	0	0	0	0	0	0
TOTAL	0	1	0	0	1	0

YP FEB 19

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
70	0	0	0	0	0	0
80	0	0	1	0	1	0
90	0	0	0	0	0	0
110	0	0	0	0	0	0
130	0	0	0	0	0	0
140	0	0	0	0	0	0
150	1	0	0	0	1	0
160	0	0	0	0	0	0
180	0	0	0	0	0	0
TOTAL	1	0	1	0	2	0

YP FEB 28

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
70	0	0	0	0	0	0
80	0	0	0	0	0	0
90	0	0	0	0	0	0
110	0	0	0	0	0	0
130	0	1	0	0	1	0
140	0	0	0	0	0	0
150	0	0	0	0	0	0
160	0	0	0	0	0	0
180	0	0	0	0	0	0
TOTAL	0	1	0	0	1	0

YP MAR 5

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
90	0	0	1	0	1	0
100	0	0	0	0	0	0
120	0	0	0	0	0	0
130	2	1	0	0	3	0
140	1	0	1	2	4	0
150	0	0	0	1	1	0
160	0	1	1	0	2	0
170	1	0	2	0	3	0
180	1	2	0	2	5	0
190	1	0	0	0	1	0
200	0	0	1	0	1	0
350	0	1	0	0	1	0
TOTAL	6	5	6	5	22	0

YP MAR 14

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
90	0	0	0	0	0	0
100	1	0	0	0	1	0
120	0	1	0	0	1	0
130	1	0	2	0	3	0
140	1	0	3	0	4	0
150	2	1	0	0	3	0
160	0	0	0	0	0	0
170	0	0	0	0	0	0
180	0	0	0	0	0	0
190	0	0	0	0	0	0
200	0	0	0	0	0	0
350	0	0	0	0	0	0
TOTAL	5	2	5	0	12	0

YP MAR 21

LINIV	DAY	DSK	NGT	DWN	(TOT	I/24)
90	0	0	0	0	0	0
100	0	0	0	0	0	0
120	1	0	3	2	6	0
130	0	0	0	0	0	0
140	0	0	0	0	0	0
150	0	0	1	0	1	0
160	0	0	1	0	1	0
170	0	1	0	0	1	0
180	0	0	0	1	1	0
190	0	0	0	0	0	0
200	0	0	0	0	0	0
350	0	0	0	0	0	0
TOTAL	1	1	5	3	10	0

Appendix 8. Continued.

YP APR 7

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
70	0	0	0	0	0	0
80	0	1	0	0	1	0
120	0	1	0	0	1	0
130	0	0	2	0	2	0
140	0	1	0	1	2	0
150	0	0	0	0	0	0
160	0	0	0	0	0	0
170	0	0	0	0	0	0
280	0	0	0	0	0	0
340	0	0	0	0	0	0
TOTAL	0	3	2	1	6	0

YP APR 11

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
70	0	1	0	0	1	0
80	0	0	0	0	0	0
120	0	0	0	1	1	0
130	4	1	1	0	6	0
140	1	0	1	2	4	0
150	0	0	0	0	0	0
160	0	0	0	0	0	0
170	0	0	0	0	0	0
280	1	0	0	0	1	0
340	1	0	0	0	1	0
TOTAL	7	2	2	3	14	0

YP APR 16

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
70	0	0	0	0	0	0
80	0	0	0	0	0	0
120	1	0	0	0	1	0
130	2	1	1	2	6	0
140	3	0	0	0	3	0
150	0	0	0	0	0	0
160	1	0	0	0	1	0
170	1	0	0	0	1	0
280	0	0	0	0	0	0
340	0	0	0	0	0	0
TOTAL	8	1	1	2	12	0

YP APR 25

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
70	0	0	0	0	0	0
80	0	0	0	0	0	0
120	0	0	0	0	0	0
130	0	0	0	0	0	0
140	0	0	0	0	0	0
150	1	1	0	0	2	0
160	0	0	0	0	0	0
170	0	0	0	0	0	0
280	0	0	0	0	0	0
340	0	0	0	0	0	0
TOTAL	1	1	0	0	2	0

YP MAY 2

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	0	0	0	0	0
130	1	0	0	0	1	0
140	0	0	0	0	0	0
150	0	0	0	0	0	0
160	1	0	1	0	2	0
190	0	0	0	0	0	0
TOTAL	2	0	1	0	3	0

YP MAY 17

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	1	0	0	0	1	0
130	2	0	0	0	2	0
140	0	0	0	1	1	0
150	0	0	0	0	0	0
160	0	0	0	0	0	0
190	1	0	0	0	1	0
TOTAL	4	0	0	1	5	0

YP MAY 24

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
80	0	0	0	1	1	0
130	0	0	0	1	1	0
140	0	0	0	0	0	0
150	0	0	0	1	1	0
160	0	0	0	0	0	0
190	0	0	0	0	0	0
TOTAL	0	0	0	3	3	0

YP JUN 7

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
160	0	0	0	0	0	0
200	0	0	0	0	0	0
210	0	0	0	0	0	0
240	0	1	0	0	1	0
TOTAL	0	1	0	0	1	0

YP JUN 14

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
160	1	0	0	0	1	0
200	0	0	0	0	0	0
210	0	0	0	0	0	0
240	0	0	0	0	0	0
TOTAL	1	0	0	0	1	0

YP JUN 20

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
160	0	0	1	0	1	0
200	0	0	0	0	0	0
210	0	0	0	0	0	0
240	0	0	0	0	0	0
TOTAL	0	0	1	0	1	0

YP JUN 28

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
160	0	0	0	0	0	0
200	0	0	0	1	1	0
210	0	0	1	0	1	0
240	0	0	0	0	0	0
TOTAL	0	0	1	1	2	0

YP JUL 19

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
150	1	1	0	0	2	0
160	0	0	0	0	0	0
220	0	0	0	0	0	0
TOTAL	1	1	0	0	2	0

YP JUL 25

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
150	0	0	0	0	0	0
160	1	0	0	0	1	0
220	0	1	0	0	1	0
TOTAL	1	1	0	0	2	0

YP AUG 1

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
160	0	1	0	0	1	0
170	0	0	0	0	0	0
210	1	0	0	0	1	0
TOTAL	1	1	0	0	2	0

YP AUG 7

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
160	0	0	0	0	0	0
170	0	0	1	1	2	0
210	0	0	0	0	0	0
TOTAL	0	0	1	1	2	0

YP AUG 15

LINTV	DAY	DSK	NGT	DWN	(TOT	I/24)
160	0	0	0	1	1	0
170	0	0	0	0	0	0
210	0	0	0	0	0	0
TOTAL	0	0	0	1	1	0

Appendix 8. Continued.

YP OCT 24

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
60	1	0	0	0	1	0
70	1	0	0	0	1	0
TOTAL	2	0	0	0	2	0

YP NOV 7

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	0	1	0	1	0
80	0	0	0	0	0	0
100	0	0	0	0	0	0
130	0	0	0	0	0	0
160	0	0	0	0	0	0
170	0	0	0	0	0	0
180	0	0	0	0	0	0
210	0	0	0	0	0	0
240	0	0	0	0	0	0
TOTAL	0	0	1	0	1	0

YP NOV 20

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	0	0	0	0	0
80	0	0	0	0	0	0
100	0	0	0	0	0	0
130	0	0	1	0	1	0
160	0	0	0	0	0	0
170	0	0	0	1	1	0
180	0	0	0	0	0	0
210	0	0	0	0	0	0
240	0	0	0	0	0	0
TOTAL	0	0	1	1	2	0

YP NOV 26

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	1	1	1	3	0
80	0	0	3	1	4	0
100	0	1	0	0	1	0
130	0	0	0	0	0	0
160	0	1	1	0	2	0
170	0	0	0	0	0	0
180	0	0	2	0	2	0
210	0	1	0	0	1	0
240	0	1	1	0	2	0
TOTAL	0	5	8	2	15	0

YP DEC 4

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	1	0	0	0	1	0
80	0	1	0	0	1	0
100	0	0	0	0	0	0
130	0	0	0	0	0	0
150	0	0	0	0	0	0
160	0	0	0	0	0	0
170	0	0	0	0	0	0
190	0	0	0	0	0	0
200	0	0	0	0	0	0
TOTAL	1	1	0	0	2	0

YP DEC 10

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	0	0	0	0	0
80	0	0	0	0	0	0
100	0	0	0	0	0	0
130	0	0	0	0	0	0
150	0	0	0	0	0	0
160	1	0	0	0	1	0
170	0	0	0	1	1	0
190	0	0	0	0	0	0
200	1	0	0	0	1	0
TOTAL	2	0	0	1	3	0

YP DEC 17

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	0	1	0	1	0
80	0	0	0	0	0	0
100	0	1	0	0	1	0
130	0	0	0	1	1	0
150	0	1	0	0	1	0
160	0	1	0	0	1	0
170	0	0	0	1	1	0
190	0	0	0	0	0	0
200	0	0	1	0	1	0
TOTAL	0	3	2	2	7	0

YP DEC 27

LINTV	DAY	DSK	NGT	DWN	(TOT	T/24)
70	0	1	0	0	1	0
80	0	1	1	0	2	0
100	0	0	0	0	0	0
130	0	0	0	0	0	0
150	0	1	0	0	1	0
160	0	0	0	0	0	0
170	0	0	1	0	1	0
190	0	1	0	0	1	0
200	0	0	0	0	0	0
TOTAL	0	4	2	0	6	0

APPENDIX 9

Appendix 9. Monthly summaries of impingement sampling, January-December 1979. Total numbers and weights of fish collected during the weekly sampling periods and estimated monthly impingement totals are given. * = daily average weight was less than 0.01 kg ** = because daily average weight was less than 0.01 kg, it was treated as 0.0, therefore total weight = 0.00 For purposes of calculating estimated weights, weight of one fish was assumed to be 0.05 g. *** = estimated total weight less than 0.01 kg. See Table 42 for species code identification.

MONTH: JANUARY, 1979

WEIGHT IN KILOGRAMS
TEMPERATURE IN DEGREES CENTIGRADE
PERCENTAGES ARE OF TOTAL SAMPLED THIS MONTH

SPECIES	DAILY AVG NUMBER	STD DEV NUMBER	DAILY AVG WEIGHT	STD DEV WEIGHT	PERCENT NUMBER	TOTAL NUMBER	PERCENT WEIGHT	TOTAL WEIGHT	ESTIMATED TOTALS FOR MONTH NUMBER	ESTIMATED TOTALS FOR MONTH WEIGHT
SP	10.50	7.92	0.08	0.06	1.36	53	0.23	0.40	325	2.48
AL	62.70	74.29	1.40	1.96	8.03	314	4.04	7.14	1943	43.30
SM	0.10	0.45	0.0 *	0.00	0.03	1	0.00	0.00 **	3	0.0 ***
YP	9.10	9.60	0.10	0.18	1.18	46	0.50	0.89	282	3.00
TP	9.50	4.04	0.10	0.07	1.23	48	0.46	0.82	294	3.00
CM	0.10	0.45	0.10	0.23	0.03	1	0.29	0.51	3	3.00
SS	0.30	0.55	0.0 *	0.00	0.05	2	0.01	0.01	9	0.06
CC	0.70	0.84	0.0 *	0.00	0.10	4	0.01	0.01	21	0.06
NP	0.10	0.45	0.02	0.04	0.03	1	0.05	0.09	3	0.56
GS	673.30	774.22	32.50	33.53	86.11	3367	92.04	162.94	20872	1007.50
PS	0.10	0.45	0.01	0.03	0.03	1	0.04	0.07	3	0.43
BB	0.10	0.45	0.0 *	0.00	0.03	1	0.00	0.01	3	0.06
BC	3.10	3.42	0.05	0.07	0.41	16	0.13	0.23	96	0.43
BG	0.30	0.55	0.0 *	0.01	0.05	2	0.01	0.02	9	0.12
BR	1.30	1.67	0.50	0.79	0.18	7	1.45	2.57	40	15.50
PP	0.10	0.45	0.0 *	0.00	0.03	1	0.00	0.00 **	3	0.0 ***
LB	7.10	5.07	0.10	0.13	0.92	36	0.34	0.60	220	3.00
WL	0.50	0.55	0.10	0.12	0.08	3	0.30	0.53	15	3.00
GL	0.70	1.30	0.01	0.01	0.10	4	0.02	0.03	21	0.19
SR	0.10	0.45	0.02	0.04	0.03	1	0.06	0.10	3	0.62
GF	0.10	0.45	0.01	0.02	0.03	1	0.03	0.04	3	0.25
TOTAL	779.90	858.83	35.10	36.34	100.00	3910	100.00	177.02	24171	1086.56

THERE WERE 5 DAYS ON WHICH SAMPLES WERE TAKEN.
ESTIMATED TOTALS FOR THIS MONTH ARE BASED ON 31 DAYS OF IMPINGEMENT.

Appendix 9. Continued.

MONTH: FEBRUARY, 1979

WEIGHT IN KILOGRAMS
TEMPERATURE IN DEGREES CENTIGRADE
PERCENTAGES ARE OF TOTAL SAMPLED THIS MONTH

SPECIES	DAILY AVG NUMBER	STD DEV NUMBER	DAILY AVG WEIGHT	STD DEV WEIGHT	PERCENT NUMBER	TOTAL NUMBER	PERCENT WEIGHT	TOTAL WEIGHT	ESTIMATED TOTALS FOR MONTH NUMBER	ESTIMATED TOTALS FOR MONTH WEIGHT
SP	9.50	6.61	0.07	0.05	3.04	38	0.32	0.27	266	1.89
AL	16.00	12.49	0.07	0.05	5.13	64	0.34	0.28	448	1.96
YP	3.50	4.36	0.07	0.09	1.12	14	0.33	0.28	98	1.96
TP	13.20	4.92	0.10	0.05	4.25	53	0.82	0.69	369	2.70
WS	0.50	0.58	0.30	0.43	0.16	2	1.57	1.33	14	8.30
ES	0.20	0.50	0.00 *	0.00	0.08	1	0.00	0.00 **	5	0.0 ***
MS	0.20	0.50	0.00 *	0.00	0.08	1	0.01	0.01	5	0.07
ET	0.50	1.00	0.00 *	0.05	0.16	2	0.12	0.10	14	0.07
SS	0.20	0.50	0.01	0.01	0.08	1	0.02	0.02	5	0.14
GS	264.00	229.22	19.50	17.11	84.62	1056	92.01	78.07	7392	546.00
BC	1.00	0.82	0.08	0.12	0.32	4	0.37	0.31	28	2.17
ER	1.50	1.73	0.50	0.82	0.48	6	2.75	2.34	42	14.00
LB	0.70	0.50	0.00 *	0.00	0.24	3	0.02	0.01	19	0.07
RB	0.20	0.50	0.01	0.03	0.08	1	0.06	0.05	5	0.35
WL	0.50	0.58	0.20	0.32	0.16	2	1.27	1.07	14	5.50
TOTAL	311.70	251.87	20.91	18.35	100.00	1248	100.00	84.85	8724	585.18

THERE WERE 4 DAYS ON WHICH SAMPLES WERE TAKEN.
ESTIMATED TOTALS FOR THIS MONTH ARE BASED ON 28 DAYS OF IMPINGEMENT.

MONTH: MARCH, 1979

WEIGHT IN KILOGRAMS
TEMPERATURE IN DEGREES CENTIGRADE
PERCENTAGES ARE OF TOTAL SAMPLED THIS MONTH

SPECIES	DAILY AVG NUMBER	STD DEV NUMBER	DAILY AVG WEIGHT	STD DEV WEIGHT	PERCENT NUMBER	TOTAL NUMBER	PERCENT WEIGHT	TOTAL WEIGHT	ESTIMATED TOTALS FOR MONTH NUMBER	ESTIMATED TOTALS FOR MONTH WEIGHT
SP	50.70	47.03	1.90	2.16	23.20	203	13.27	7.61	1571	58.80
AL	0.20	0.50	0.0 *	0.00	0.11	1	0.01	0.00 **	6	0.0 ***
YP	11.00	9.02	0.50	0.70	5.03	44	3.97	2.28	341	15.50
TP	11.00	10.68	0.10	0.16	5.03	44	1.19	0.68	341	3.00
WS	3.70	3.86	2.60	2.34	1.71	15	18.41	10.56	114	80.50
CH	0.70	0.50	0.10	0.13	0.34	3	1.08	0.62	21	3.00
ES	1.50	1.73	0.01	0.01	0.69	6	0.04	0.03	46	0.23
MS	0.20	0.50	0.0 *	0.01	0.11	1	0.02	0.01	6	0.08
NS	0.50	1.00	0.0 *	0.00	0.23	2	0.01	0.00 **	15	0.0 ***
SS	0.20	0.50	0.0 *	0.00	0.11	1	0.02	0.01	6	0.08
CC	0.20	0.50	0.0 *	0.00	0.11	1	0.00	0.00 **	6	0.0 ***
NP	3.00	5.35	0.20	0.33	1.37	12	1.75	1.01	93	6.10
GS	130.00	255.34	7.90	15.76	59.43	520	55.68	31.95	4030	244.80
BC	0.70	0.96	0.0 *	0.00	0.34	3	0.02	0.01	21	0.08
BF	0.20	0.50	0.20	0.57	0.11	1	2.00	1.15	6	6.10
BR	0.50	0.58	0.10	0.18	0.23	2	1.00	0.58	15	3.00
PP	0.20	0.50	0.0 *	0.00	0.11	1	0.01	0.00 **	6	0.0 ***
IB	0.70	1.50	0.01	0.01	0.34	3	0.04	0.02	21	0.16
WL	0.50	1.00	0.10	0.36	0.23	2	1.24	0.71	15	3.00
GL	1.70	2.06	0.02	0.03	0.80	7	0.15	0.09	52	0.70
SL	0.20	0.50	0.01	0.02	0.11	1	0.07	0.04	6	0.31
GF	0.20	0.50	0.0 *	0.00	0.11	1	0.01	0.01	6	0.08
BN	0.20	0.50	0.0 *	0.00	0.11	1	0.00	0.00 **	6	0.0 ***
TOTAL	218.00	282.31	13.75	14.83	100.00	875	100.00	57.37	6750	425.52

THERE WERE 4 DAYS ON WHICH SAMPLES WERE TAKEN.
ESTIMATED TOTALS FOR THIS MONTH ARE BASED ON 31 DAYS OF IMPINGEMENT.

Appendix 9. Continued.

MONTH: APRIL, 1979

WEIGHT IN KILOGRAMS
TEMPERATURE IN DEGREES CENTIGRADE
PERCENTAGES ARE OF TOTAL SAMPLED THIS MONTH

SPECIES	DAILY AVG NUMBER	STD DEV NUMBER	DAILY AVG WEIGHT	STD DEV WEIGHT	PERCENT NUMBER	TOTAL NUMBER	PERCENT WEIGHT	TOTAL WEIGHT	ESTIMATED TOTALS FOR MONTH NUMBER	ESTIMATED TOTALS FOR MONTH WEIGHT
FC	0.20	0.50	0.10	0.26	0.32	1	2.12	0.52	5	2.90
SP	23.20	22.90	0.80	1.49	29.90	93	14.02	3.43	695	23.90
SM	0.70	0.50	0.0 *	0.01	0.96	3	0.12	0.03	20	0.23
YP	8.50	5.51	0.40	0.45	10.93	34	6.67	1.63	255	11.90
TP	2.70	2.63	0.04	0.04	3.54	11	0.71	0.17	80	1.28
WS	2.50	1.29	1.90	1.09	3.22	10	31.42	7.70	75	56.90
CH	2.00	1.41	0.40	0.28	2.57	8	6.64	1.63	60	11.90
ES	0.20	0.50	0.0 *	0.00	0.32	1	0.02	0.00 **	5	0.0 ***
MS	0.70	0.96	0.01	0.01	0.96	3	0.16	0.04	20	0.30
CM	0.20	0.50	0.10	0.33	0.32	1	2.66	0.65	5	2.90
BT	0.50	0.58	0.40	0.78	0.64	2	7.11	1.74	15	11.90
NS	0.20	0.50	0.0 *	0.00	0.32	1	0.01	0.00 **	5	0.0 ***
SS	2.50	3.32	0.02	0.03	3.22	10	0.28	0.07	75	0.53
CC	0.50	1.00	0.10	0.33	0.64	2	2.72	0.67	15	2.90
NP	1.50	1.00	0.10	0.11	1.93	6	2.28	0.56	45	2.90
GS	17.00	25.78	0.80	1.45	21.86	68	13.91	3.41	510	23.90
PS	1.20	0.96	0.03	0.05	1.61	5	0.44	0.11	35	0.83
BB	1.00	0.82	0.10	0.08	1.29	4	1.69	0.41	30	2.90
BC	4.50	4.73	0.04	0.05	5.79	18	0.68	0.17	135	1.28
BG	0.20	0.50	0.0 *	0.00	0.32	1	0.04	0.01	5	0.08
BF	0.20	0.50	0.10	0.38	0.32	1	3.10	0.76	5	2.90
BR	0.70	0.50	0.10	0.20	0.96	3	2.33	0.57	20	2.90
PP	0.70	1.50	0.0 *	0.01	0.96	3	0.05	0.01	20	0.08
LB	1.20	1.50	0.01	0.01	1.61	5	0.16	0.04	35	0.30
GL	4.00	4.90	0.04	0.04	5.14	16	0.62	0.15	120	1.13
GF	0.20	0.50	0.0 *	0.01	0.32	1	0.05	0.01	5	0.08
TOTAL	77.00	72.49	5.59	4.79	100.00	311	100.00	24.50	2295	166.82

THERE WERE 4 DAYS ON WHICH SAMPLES WERE TAKEN.
ESTIMATED TOTALS FOR THIS MONTH ARE BASED ON 30 DAYS OF IMPINGEMENT.

MONTH: MAY, 1979

WEIGHT IN KILOGRAMS
TEMPERATURE IN DEGREES CENTIGRADE
PERCENTAGES ARE OF TOTAL SAMPLED THIS MONTH

SPECIES	DAILY AVG NUMBER	STD DEV NUMBER	DAILY AVG WEIGHT	STD DEV WEIGHT	PERCENT NUMBER	TOTAL NUMBER	PERCENT WEIGHT	TOTAL WEIGHT	ESTIMATED TOTALS FOR MONTH NUMBER	ESTIMATED TOTALS FOR MONTH WEIGHT
SP	9.00	3.27	0.09	0.04	25.00	36	4.89	0.37	279	2.87
AL	19.20	19.52	1.40	2.22	53.47	77	77.13	5.90	595	43.30
SM	0.70	1.50	0.02	0.03	2.08	3	0.84	0.06	21	0.47
YP	2.70	2.06	0.09	0.07	7.64	11	4.66	0.36	83	2.79
TP	0.50	0.58	0.0 *	0.01	1.39	2	0.33	0.02	15	0.16
WS	0.20	0.50	0.10	0.19	0.69	1	5.01	0.38	6	2.95
LT	0.20	0.50	0.0 *	0.01	0.69	1	0.24	0.02	6	0.16
CH	0.50	0.58	0.05	0.08	1.39	2	2.32	0.18	15	1.40
ES	0.20	0.50	0.0 *	0.00	0.69	1	0.11	0.01	6	0.08
CM	0.20	0.50	0.02	0.04	0.69	1	0.93	0.07	6	0.54
NS	1.00	1.41	0.0 *	0.00	2.78	4	0.12	0.01	31	0.08
GS	0.20	0.50	0.01	0.02	0.69	1	0.39	0.03	6	0.23
BC	0.50	0.58	0.0 *	0.00	1.39	2	0.10	0.01	15	0.08
BR	0.20	0.50	0.01	0.02	0.69	1	0.43	0.03	6	0.23
GF	0.20	0.50	0.05	0.10	0.69	1	2.51	0.19	6	1.47
TOTAL	35.50	19.04	1.84	2.19	100.00	144	100.00	7.65	1096	56.81

THERE WERE 4 DAYS ON WHICH SAMPLES WERE TAKEN.
ESTIMATED TOTALS FOR THIS MONTH ARE BASED ON 31 DAYS OF IMPINGEMENT.

Appendix 9. Continued.

MONTH: JUNE, 1979

WEIGHT IN KILOGRAMS
TEMPERATURE IN DEGREES CENTIGRADE
PERCENTAGES ARE OF TOTAL SAMPLED THIS MONTH

SPECIES	DAILY AVG NUMBER	STD DEV NUMBER	DAILY AVG WEIGHT	STD DEV WEIGHT	PERCENT NUMBER	TOTAL NUMBER	PERCENT WEIGHT	TOTAL WEIGHT	ESTIMATED TOTALS FOR MONTH NUMBER	ESTIMATED TOTALS FOR MONTH WEIGHT
SP	9.50	0.0	0.10	0.0	3.07	38	0.68	0.47	285	2.90
AL	295.20	102.19	16.90	5.57	95.55	1181	98.04	67.71	8855	506.90
SM	0.50	0.58	0.0 *	0.01	0.16	2	0.04	0.03	15	0.23
YP	1.20	0.0	0.10	0.03	0.40	5	0.68	0.47	35	2.90
NS	0.50	0.58	0.0 *	0.00	0.16	2	0.01	0.01	15	0.08
SB	0.20	0.50	0.02	0.04	0.08	1	0.10	0.07	5	0.53
NP	0.20	0.50	0.0 *	0.00	0.08	1	0.01	0.01	5	0.08
BB	0.50	0.58	0.04	0.05	0.16	2	0.24	0.16	15	1.20
BC	0.20	0.50	0.0 *	0.00	0.08	1	0.01	0.01	5	0.08
CS	0.20	0.50	0.01	0.01	0.08	1	0.03	0.02	5	0.15
RB	0.20	0.50	0.03	0.05	0.08	1	0.14	0.10	5	0.75
MT	0.20	0.50	0.0 *	0.00	0.08	1	0.01	0.01	5	0.08
TOTAL	308.60	75.47	17.20	4.77	100.00	1236	100.00	69.07	9250	515.88

THERE WERE 4 DAYS ON WHICH SAMPLES WERE TAKEN.
ESTIMATED TOTALS FOR THIS MONTH ARE BASED ON 30 DAYS OF IMPINGEMENT.

Appendix 9. Continued.

MONTH: JULY, 1979

WEIGHT IN KILOGRAMS
TEMPERATURE IN DEGREES CENTIGRADE
PERCENTAGES ARE OF TOTAL SAMPLED THIS MONTH

SPECIES	DAILY AVG NUMBER	STD DEV NUMBER	DAILY AVG WEIGHT	STD DEV WEIGHT	PERCENT NUMBER	TOTAL NUMBER	PERCENT WEIGHT	TOTAL WEIGHT	ESTIMATED TOTALS FOR MONTH NUMBER	ESTIMATED TOTALS FOR MONTH WEIGHT
SP	47.50	44.83	1.20	1.53	13.51	190	6.13	5.08	1472	37.10
AL	298.20	310.24	19.30	14.99	84.85	1193	93.24	77.32	9244	598.20
SM	0.70	0.96	0.01	0.01	0.21	3	0.03	0.03	21	0.23
YP	1.00	1.15	0.07	0.09	0.28	4	0.31	0.26	31	2.02
TP	0.20	0.50	0.0 *	0.00	0.07	1	0.00	0.00 **	6	0.0 ***
CH	0.50	0.58	0.01	0.01	0.14	2	0.02	0.02	15	0.16
NS	0.50	0.58	0.0 *	0.00	0.14	2	0.00	0.00 **	15	0.0 ***
NP	1.00	0.82	0.02	0.03	0.28	4	0.10	0.09	31	0.70
GS	0.20	0.50	0.01	0.02	0.07	1	0.04	0.04	6	0.31
BB	0.20	0.50	0.01	0.03	0.07	1	0.06	0.05	6	0.39
BC	1.00	2.00	0.01	0.02	0.28	4	0.04	0.04	31	0.31
MT	0.20	0.50	0.0 *	0.00	0.07	1	0.00	0.00 **	6	0.0 ***
TOTAL	351.20	298.03	20.64	14.93	100.00	1406	100.00	82.93	10884	639.42

THERE WERE 4 DAYS ON WHICH SAMPLES WERE TAKEN.
ESTIMATED TOTALS FOR THIS MONTH ARE BASED ON 31 DAYS OF IMPINGEMENT.

Appendix 9. Continued.

MONTH: AUGUST, 1979

WEIGHT IN KILOGRAMS
TEMPERATURE IN DEGREES CENTIGRADE
PERCENTAGES ARE OF TOTAL SAMPLED THIS MONTH

SPECIES	DAILY AVG NUMBER	STD DEV NUMBER	DAILY AVG WEIGHT	STD DEV WEIGHT	PERCENT NUMBER	TOTAL NUMBER	PERCENT WEIGHT	TOTAL WEIGHT	ESTIMATED TOTALS FOR MONTH NUMBER	ESTIMATED TOTALS FOR MONTH WEIGHT
SP	7.50	4.34	0.06	0.04	5.44	38	2.45	0.30	232	1.86
AL	87.50	124.03	1.40	1.10	62.75	438	61.67	7.46	2712	43.30
SM	29.50	32.88	0.20	0.47	21.20	148	9.41	1.14	914	6.10
YP	1.00	1.00	0.07	0.07	0.72	5	2.72	0.33	31	2.05
LS	0.10	0.45	0.0 *	0.00	0.14	1	0.06	0.01	3	0.06
CH	0.10	0.45	0.0 *	0.01	0.14	1	0.20	0.02	3	0.12
CM	0.10	0.45	0.0 *	0.01	0.14	1	0.24	0.03	3	0.19
ET	0.10	0.45	0.0 *	0.01	0.14	1	0.21	0.03	3	0.19
GS	10.30	11.01	0.20	0.49	7.45	52	10.76	1.30	319	6.10
BC	0.30	0.55	0.04	0.07	0.29	2	1.51	0.18	9	1.12
BF	0.10	0.45	0.20	0.51	0.14	1	9.51	1.15	3	6.10
LB	1.10	0.84	0.0 *	0.00	0.86	6	0.18	0.02	34	0.12
RB	0.10	0.45	0.02	0.05	0.14	1	1.00	0.12	3	0.74
MT	0.50	0.89	0.0 *	0.00	0.43	3	0.09	0.01	15	0.06
TOTAL	138.30	140.00	2.19	1.54	100.00	698	100.00	12.10	4284	68.11

THERE WERE 5 DAYS ON WHICH SAMPLES WERE TAKEN.
ESTIMATED TOTALS FOR THIS MONTH ARE BASED ON 31 DAYS OF IMPINGEMENT.

Appendix 9. Continued.

MONTH: SEPTEMBER, 1979

WEIGHT IN KILOGRAMS
TEMPERATURE IN DEGREES CENTIGRADE
PERCENTAGES ARE OF TOTAL SAMPLED THIS MONTH

SPECIES	DAILY AVG NUMBER	STD DEV NUMBER	DAILY AVG WEIGHT	STD DEV WEIGHT	PERCENT NUMBER	TOTAL NUMBER	PERCENT WEIGHT	TOTAL WEIGHT	ESTIMATED TOTALS FOR MONTH NUMBER	ESTIMATED TOTALS FOR MONTH WEIGHT
SP	2.20	2.06	0.02	0.02	0.69	9	0.34	0.08	65	0.60
AL	306.20	190.65	4.70	3.22	93.51	1225	87.23	19.02	9185	140.90
SM	10.20	11.09	0.03	0.05	3.13	41	0.55	0.12	305	0.90
TP	1.20	1.26	0.01	0.01	0.38	5	0.19	0.04	35	0.30
LT	0.20	0.50	0.60	1.21	0.08	1	11.10	2.42	5	17.90
ES	0.20	0.50	0.0 *	0.00	0.08	1	0.02	0.00 **	5	0.0 ***
CC	0.20	0.50	0.0 *	0.00	0.08	1	0.01	0.00 **	5	0.0 ***
GS	6.00	2.94	0.03	0.01	1.83	24	0.53	0.11	180	0.83
XC	0.50	0.58	0.0 *	0.00	0.15	2	0.02	0.00 **	15	0.0 ***
MT	0.20	0.50	0.0 *	0.00	0.08	1	0.01	0.00 **	5	0.0 ***
TOTAL	327.10	201.37	5.39	3.66	100.00	1310	100.00	21.80	9805	161.43

THERE WERE 4 DAYS ON WHICH SAMPLES WERE TAKEN.
ESTIMATED TOTALS FOR THIS MONTH ARE BASED ON 30 DAYS OF IMPINGEMENT.

Appendix 9. Continued.

MONTH: OCTOBER, 1979

WEIGHT IN KILOGRAMS
TEMPERATURE IN DEGREES CENTIGRADE
PERCENTAGES ARE OF TOTAL SAMPLED THIS MONTH

SPECIES	DAILY AVG NUMBER	STD DEV NUMBER	DAILY AVG WEIGHT	STD DEV WEIGHT	PERCENT NUMBER	TOTAL NUMBER	PERCENT WEIGHT	TOTAL WEIGHT	ESTIMATED TOTALS FOR MONTH NUMBER	ESTIMATED TOTALS FOR MONTH WEIGHT
SP	3.70	2.28	0.04	0.02	0.85	19	0.55	0.19	114	1.18
AL	366.00	530.15	3.50	4.07	81.70	1830	50.11	17.69	11346	108.50
SM	16.10	15.14	0.30	0.48	3.62	81	4.65	1.64	499	9.20
YP	0.30	0.89	0.0 *	0.00	0.09	2	0.02	0.01	9	0.06
TP	4.00	7.38	0.07	0.13	0.89	20	0.94	0.33	124	2.05
LT	0.10	0.45	0.50	1.12	0.04	1	7.08	2.50	3	15.50
CH	0.10	0.45	0.10	0.25	0.04	1	1.56	0.55	3	3.00
CM	0.30	0.89	0.10	0.32	0.09	2	2.03	0.72	9	3.00
NS	0.10	0.45	0.0 *	0.00	0.04	1	0.00	0.00 **	3	0.0 ***
SB	0.10	0.45	0.01	0.02	0.04	1	0.14	0.05	3	0.31
GS	29.00	31.30	1.20	1.74	6.47	145	17.52	6.19	899	37.10
XC	0.10	0.45	0.0 *	0.00	0.04	1	0.01	0.00 **	3	0.0 ***
PS	0.10	0.45	0.0 *	0.00	0.04	1	0.02	0.01	3	0.06
BC	0.50	0.89	0.0 *	0.00	0.13	3	0.04	0.01	15	0.06
BG	2.30	3.91	0.0 *	0.01	0.54	12	0.10	0.03	71	0.19
ER	0.10	0.45	0.10	0.25	0.04	1	1.56	0.55	3	3.00
LB	23.10	45.24	0.80	1.77	5.18	116	11.71	4.14	716	24.70
LP	0.10	0.45	0.0 *	0.00	0.04	1	0.02	0.01	3	0.06
BN	0.30	0.55	0.10	0.27	0.09	2	1.95	0.69	9	3.00
TOTAL	446.40	618.75	6.82	8.47	100.00	2240	100.00	35.31	13835	210.97

THERE WERE 5 DAYS ON WHICH SAMPLES WERE TAKEN.
ESTIMATED TOTALS FOR THIS MONTH ARE BASED ON 31 DAYS OF IMPINGEMENT.

Appendix 9. Continued.

MONTH: NOVEMBER, 1979

WEIGHT IN KILOGRAMS
TEMPERATURE IN DEGREES CENTIGRADE
PERCENTAGES ARE CF TOTAL SAMPLED THIS MONTH

SPECIES	DAILY AVG NUMBER	STD DEV NUMBER	DAILY AVG WEIGHT	STD DEV WEIGHT	PERCENT NUMBER	TOTAL NUMBER	PERCENT WEIGHT	TOTAL WEIGHT	ESTIMATED TOTALS FOR MONTH NUMBER	ESTIMATED TOTALS FOR MONTH WEIGHT
SP	20.00	31.36	0.80	1.61	1.92	80	4.49	3.40	600	23.90
AL	835.70	466.02	11.30	3.85	80.07	3343	59.72	45.20	25070	338.90
SM	19.50	17.75	0.40	0.79	1.87	78	2.17	1.65	585	11.90
YP	4.50	7.05	0.10	0.34	0.43	18	1.04	0.78	135	2.90
TP	17.70	5.91	0.30	0.09	1.70	71	1.66	1.26	530	8.90
LT	0.20	0.50	0.70	1.52	0.02	1	4.03	3.05	5	20.90
CH	0.70	0.50	0.40	0.31	0.07	3	2.38	1.80	20	11.90
CP	0.20	0.50	0.0 *	0.01	0.02	1	0.02	0.01 **	5	0.08
MS	0.20	0.50	0.0 *	0.00	0.02	1	0.01	0.00 **	5	0.0 ***
SS	0.20	0.50	0.0 *	0.00	0.02	1	0.00	0.00 **	5	0.0 ***
GS	135.50	183.13	4.40	7.62	12.98	542	23.47	17.76	4065	131.90
XC	1.70	1.71	0.01	0.01	0.17	7	0.03	0.02	50	0.15
PS	0.20	0.50	0.01	0.02	0.02	1	0.07	0.05	5	0.38
BB	0.20	0.50	0.01	0.02	0.02	1	0.04	0.03	5	0.23
BC	0.50	1.00	0.01	0.03	0.05	2	0.07	0.05	15	0.38
BG	1.50	1.91	0.01	0.01	0.14	6	0.02	0.02	45	0.15
IB	3.20	3.86	0.02	0.03	0.31	13	0.12	0.09	95	0.68
RB	0.50	0.58	0.02	0.04	0.05	2	0.11	0.09	15	0.68
YB	0.20	0.50	0.01	0.02	0.02	1	0.06	0.04	5	0.30
SL	0.20	0.50	0.08	0.15	0.02	1	0.41	0.31	5	2.33
MT	0.20	0.50	0.0 *	0.00	0.02	1	0.01	0.01	5	0.08
BN	0.20	0.50	0.02	0.03	0.02	1	0.07	0.06	5	0.45
TOTAL	1043.00	562.08	18.59	9.11	100.00	4175	100.00	75.68	31275	557.09

THERE WERE 4 DAYS ON WHICH SAMPLES WERE TAKEN.
ESTIMATED TOTALS FOR THIS MONTH ARE BASED ON 30 DAYS OF IMPINGEMENT.

Appendix 9. Continued.

MONTH: DECEMBER, 1979

WEIGHT IN KILOGRAMS
TEMPERATURE IN DEGREES CENTIGRADE
PERCENTAGES ARE OF TOTAL SAMPLED THIS MONTH

SPECIES	DAILY AVG NUMBER	STD DEV NUMBER	DAILY AVG WEIGHT	STD DEV WEIGHT	PERCENT NUMBER	TOTAL NUMBER	PERCENT WEIGHT	TOTAL WEIGHT	ESTIMATED TOTALS FOR MONTH NUMBER	ESTIMATED TOTALS FOR MONTH WEIGHT
SP	6.70	3.10	0.06	0.02	3.86	27	0.65	0.23	207	1.78
AL	63.50	59.66	1.20	2.10	36.34	254	14.60	5.04	1968	37.10
SM	4.20	2.99	0.02	0.03	2.43	17	0.24	0.08	130	0.62
YP	4.50	0.58	0.10	0.10	2.58	18	2.01	0.69	139	3.00
TP	8.70	3.86	0.10	0.03	5.01	35	1.52	0.52	269	3.00
WS	0.20	0.50	0.04	0.08	0.14	1	0.48	0.16	6	1.24
LT	0.20	0.50	0.90	1.85	0.14	1	10.72	3.70	6	27.80
CH	0.20	0.50	0.10	0.32	0.14	1	1.84	0.63	6	3.00
RT	0.20	0.50	0.60	1.40	0.14	1	8.12	2.80	6	18.50
NS	0.20	0.50	0.0 *	0.00	0.14	1	0.01	0.00 **	6	0.0 ***
CC	0.20	0.50	0.10	0.36	0.14	1	2.06	0.71	6	3.00
QL	1.20	1.26	0.10	0.14	0.72	5	1.23	0.42	37	3.00
NP	3.50	3.11	0.10	0.06	2.00	14	1.09	0.38	108	2.95
GS	74.00	76.34	4.10	4.58	42.35	296	47.56	16.41	2294	127.00
BB	0.50	1.00	0.03	0.06	0.29	2	0.35	0.12	15	0.93
BC	2.00	0.82	0.02	0.02	1.14	8	0.17	0.06	62	0.47
BG	0.50	1.00	0.0 *	0.00	0.29	2	0.01	0.00 **	15	0.0 ***
LB	2.00	2.31	0.01	0.01	1.14	8	0.14	0.05	62	0.39
WL	1.00	2.00	0.60	1.24	0.57	4	7.17	2.47	31	18.50
GL	0.20	0.50	0.0 *	0.00	0.14	1	0.02	0.01	6	0.08
MT	0.20	0.50	0.0 *	0.00	0.14	1	0.01	0.00 **	6	0.0 ***
BN	0.20	0.50	0.0 *	0.00	0.14	1	0.00	0.00 **	6	0.0 ***
TOTAL	174.10	141.62	8.18	9.31	100.00	699	100.00	34.50	5391	252.36

THERE WERE 4 DAYS ON WHICH SAMPLES WERE TAKEN.
ESTIMATED TOTALS FOR THIS MONTH ARE BASED ON 31 DAYS OF IMPINGEMENT.

APPENDIX 10

Appendix 10. Number of fish larvae and eggs per 1000 m^3 for north transect stations in Lake Michigan (Fig. 1) near the J. H. Campbell Plant, eastern Lake Michigan, April to September 1979. D = day, N = night, * = sled tow. See Table 42 for species code identification.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
4-18-79	D	Q	0.5	9.0													0	0
4-18-79	D	Q	0.5	9.0													0	0
4-17-79	D	Q*	1.0	7.6													0	0
4-18-79	N	Q	0.5	8.5													0	0
4-18-79	N	Q	0.5	8.5													0	0
4-17-79	N	Q*	1.0	7.0		24											24	0
4-18-79	D	R	0.5	11.0													0	0
4-18-79	D	R	0.5	11.0												XS: 191	191	0
4-18-79	N	R	0.5	7.5													0	0
4-18-79	N	R	0.5	7.5													0	0
4-17-79	D	I	0.5	8.6													0	0
4-17-79	D	I*	1.5	7.6													0	0
4-16-79	N	I	0.5	8.3													0	0
4-17-79	N	I*	1.5	7.3													0	0
4-17-79	D	J	0.5	8.4													0	0
4-17-79	D	J	2.5	8.0													0	0
4-17-79	D	J*	3.0	8.0													0	0
4-16-79	N	J	0.5	7.5													0	0
4-16-79	N	J	2.5	9.2													0	0
4-17-79	N	J*	3.0	7.0													0	0
4-17-79	D	L	0.5	3.5													0	0
4-17-79	D	L	2.0	3.5													0	0
4-17-79	D	L	4.0	3.5												FS: 17	17	0
4-17-79	D	L	5.5	3.8													0	0
4-17-79	D	L*	6.0	3.8													0	0
4-17-79	N	L	0.5	2.5													0	0
4-17-79	N	L	2.0	2.5													0	0
4-17-79	N	L	4.0	2.5													0	0
4-17-79	N	L	5.5	3.0													0	0
4-17-79	N	L*	6.0	3.9													0	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
4-17-79	D	N	0.5	2.5													0	0
4-17-79	D	N	2.5	2.5													0	0
4-17-79	D	N	4.5	2.5													0	0
4-17-79	D	N	6.5	2.5													0	0
4-17-79	D	N	8.5	2.5													0	0
4-17-79	D	N*	9.0	2.5													0	0
4-17-79	N	N	0.5	2.0													0	0
4-17-79	N	N	2.5	2.3													0	0
4-17-79	N	N	4.5	2.3													0	0
4-17-79	N	N	6.5	2.3													0	0
4-17-79	N	N	8.5	2.3												FS: 17	17	0
4-18-79	N	N*	9.0	2.5													0	0
4-17-79	D	O	0.5	2.3													0	0
4-17-79	D	O	3.0	2.3													0	0
4-17-79	D	O	6.0	2.3													0	0
4-17-79	D	O	9.0	2.3													0	0
4-17-79	D	O	11.0	2.3													0	0
4-17-79	D	O*	12.0	2.3													0	0
4-17-79	N	O	0.5	1.5													0	0
4-17-79	N	O	3.0	1.9													0	0
4-17-79	N	O	6.0	1.9													0	0
4-17-79	N	O	9.0	1.9													0	0
4-17-79	N	O	11.0	2.0													0	0
4-18-79	N	O*	12.0	2.5													0	0
4-17-79	D	W	0.5	2.3													0	0
4-17-79	D	W	4.5	2.3													0	0
4-17-79	D	W	8.5	2.3													0	0
4-17-79	D	W	11.5	2.3													0	0
4-17-79	D	W	14.0	2.1													0	0
4-17-79	D	W*	15.0	2.1													0	0
4-17-79	N	W	0.5	1.1													0	0
4-17-79	N	W	4.5	1.1													0	0
4-17-79	N	W	8.5	1.1													0	0
4-17-79	N	W	11.5	1.1													0	0
4-17-79	N	W	14.0	1.5													0	0
4-18-79	N	W*	15.0	2.0													0	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
5-14-79	D	Q	0.5	14.2			291	145									436	145
5-14-79	D	Q	0.5	14.2			595										595	0
5-15-79	D	Q*	1.0	14.6		341		292				195					828	0
5-14-79	N	Q	0.5	13.0													0	0
5-14-79	N	Q	0.5	13.0			1880	341									2221	0
5-16-79	N	Q*	1.0	12.8				98								PM: 49	147	0
5-14-79	D	R	0.5	14.6													0	0
5-14-79	D	R	0.5	14.6			175	175		175							525	0
5-14-79	N	R	0.5	13.5				533									533	0
5-14-79	N	R	0.5	13.5													0	0
5-15-79	D	I	0.5	13.5				129				25					154	0
5-15-79	D	I*	1.5	14.5		50		1050									1100	0
5-16-79	N	I	0.5	13.4		24		49				49					122	0
5-16-79	N	I*	1.5	12.8													0	0
5-15-79	D	J	0.5	13.3			32					32					64	0
5-15-79	D	J	2.5	13.0			28	228									256	0
5-15-79	D	J*	3.0	12.5			230	25		25							280	0
5-16-79	N	J	0.5	12.7		26	79	106		26							237	0
5-16-79	N	J	2.5	12.7			26									PM: 26	52	0
5-16-79	N	J*	3.0	12.8				142				47					189	0
5-16-79	D	L	0.5	12.9													0	0
5-16-79	D	L	2.0	11.9			21	84								PM: 21	126	0
5-16-79	D	L	4.0	11.9			15			15		15					45	0
5-16-79	D	L	5.5	10.9													0	0
5-15-79	D	L*	6.0	12.4													0	0
5-16-79	N	L	0.5	12.5		23		23									46	0
5-16-79	N	L	2.0	12.0		45	15	61									121	0
5-16-79	N	L	4.0	12.0		24	24	24				24					96	0
5-16-79	N	L	5.5	11.8			16										16	0
5-16-79	N	L*	6.0	11.8													0	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
5-16-79	D	N	0.5	11.6													0	0
5-16-79	D	N	2.5	10.8			24	170									194	0
5-16-79	D	N	4.5	10.8				47		15							62	0
5-16-79	D	N	6.5	10.8				24									24	0
5-16-79	D	N	8.5	10.6													0	0
5-15-79	D	N*	9.0	11.2													0	0
5-16-79	N	N	0.5	11.2													0	0
5-16-79	N	N	2.5	10.2				29		14							43	0
5-16-79	N	N	4.5	10.2			15										15	0
5-16-79	N	N	6.5	10.2													0	0
5-16-79	N	N	8.5	9.5													0	0
5-16-79	N	N*	9.0	11.0													0	0
5-16-79	D	O	0.5	11.2		23	23										46	0
5-16-79	D	O	3.0	10.0				15									15	0
5-16-79	D	O	9.0	10.0			14										14	0
5-16-79	D	O	11.0	10.2				18								FS: 18	36	0
5-15-79	D	O*	12.0	11.8													0	0
5-15-79	N	O	0.5	11.0			24	24									48	0
5-15-79	N	O	3.0	9.5			16					16					32	0
5-15-79	N	O	6.0	9.5			23										23	0
5-15-79	N	O	9.0	9.5													0	0
5-15-79	N	O	11.0	9.5													0	0
5-16-79	N	O*	12.0	10.0										37			37	0
5-16-79	D	W	0.5	12.2													0	0
5-16-79	D	W	4.5	11.0						28							28	0
5-16-79	D	W	8.5	11.0													0	0
5-16-79	D	W	11.5	11.0													0	0
5-16-79	D	W	14.0	10.8													0	0
5-15-79	D	W*	15.0	11.5			22										22	0
5-15-79	N	W	0.5	12.0													0	0
5-15-79	N	W	4.5	9.8			27							27			54	0
5-15-79	N	W	8.5	9.8													0	0
5-15-79	N	W	11.5	9.8													0	0
5-15-79	N	W	14.0	9.5													0	0
5-16-79	N	W*	15.0	6.8													0	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
6-05-79	D	Q	0.5	13.5	935	233											1168	233
6-05-79	D	Q	0.5	13.5	233												233	0
6-05-79	D	Q*	1.0	13.0	91												91	30
6-05-79	N	Q	0.5	13.0													0	0
6-05-79	N	Q	0.5	13.0													0	0
6-04-79	N	Q*	1.0	13.0													0	35
6-05-79	D	R	0.5	14.0													0	0
6-05-79	D	R	0.5	14.0													0	0
6-05-79	D	R*	1.0	13.5													0	933
6-05-79	N	R	0.5	13.0		688											688	0
6-05-79	N	R	0.5	13.0	229	918											1147	0
6-04-79	N	R*	1.0	13.6													0	217
6-05-79	D	I	0.5	14.0													0	0
6-05-79	D	I*	1.5	13.5													0	0
6-04-79	N	I	0.5	13.5		90											90	0
6-04-79	N	I*	1.5	13.0													0	87
6-05-79	D	J	0.5	13.5													0	0
6-05-79	D	J	2.5	13.0	37		37										74	0
6-05-79	D	J*	3.0	13.0													0	198
6-04-79	N	J	0.5	13.5	90												90	0
6-04-79	N	J	2.5	11.5		90											90	0
6-04-79	N	J*	3.0	12.5					55								55	0
6-05-79	D	L	0.5	12.0													0	0
6-05-79	D	L	2.0	11.2													0	0
6-05-79	D	L	4.0	11.2													0	0
6-05-79	D	L	5.5	11.3	12		12										24	0
6-05-79	D	L*	6.0	9.8													0	0
6-06-79	N	L	0.5	10.0													0	0
6-06-79	N	L	2.0	10.0													0	0
6-06-79	N	L	4.0	10.0			15										15	0
6-06-79	N	L	5.5	10.0													0	0
6-04-79	N	L*	6.0	11.5													0	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
6-05-79	D	N	0.5	11.5			15										15	0
6-05-79	D	N	2.5	10.8			36										36	0
6-05-79	D	N	4.5	10.8			29										29	0
6-05-79	D	N	6.5	10.8													0	0
6-05-79	D	N	8.5	11.0													0	0
6-05-79	D	N*	9.0	9.8													0	0
6-06-79	N	N	0.5	10.0													0	0
6-06-79	N	N	2.5	10.0			33	16									49	0
6-06-79	N	N	4.5	10.0													0	824
6-06-79	N	N	6.5	10.0			15										15	0
6-06-79	N	N	8.5	9.9			15										15	0
6-04-79	N	N*	9.0	11.0			30										30	0
6-05-79	D	O	0.5	11.8													0	0
6-05-79	D	O	3.0	10.5			76										76	0
6-05-79	D	O	6.0	10.5			18										18	0
6-05-79	D	O	9.0	10.5	13		40										53	0
6-05-79	D	O	11.0	10.5													0	0
6-05-79	D	O*	12.0	9.8													0	0
6-05-79	N	O	0.5	10.2													0	0
6-05-79	N	O	3.0	9.2			17										17	0
6-05-79	N	O	6.0	9.2													0	0
6-05-79	N	O	9.0	9.2			14										14	0
6-06-79	N	O	11.0	9.8			31										31	0
6-04-79	N	O*	12.0	11.0			69										69	0
6-05-79	D	W	0.5	11.0													0	0
6-05-79	D	W	4.5	9.9			13										13	0
6-05-79	D	W	8.5	9.9			17										17	36
6-05-79	D	W	11.5	9.9													0	0
6-05-79	D	W	14.0	9.9													0	0
6-05-79	D	W*	15.0	10.0													0	0
6-05-79	N	W	0.5	11.0			17										17	0
6-05-79	N	W	4.5	9.0													0	0
6-05-79	N	W	8.5	9.0			17										17	0
6-05-79	N	W	11.5	9.0													0	0
6-05-79	N	W	14.0	7.9													0	0
6-04-79	N	W*	15.0	10.0			25										25	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
6-20-79	D	Q	0.5	16.5		315											315	1103
6-20-79	D	Q	0.5	16.5												XM: 74	74	0
6-19-79	D	Q*	1.0	14.0													0	139
6-20-79	N	Q	0.5	14.2													0	25641
6-20-79	N	Q	0.5	14.2													0	8484
6-19-79	N	Q*	1.0	12.7	42	42		42									126	42
6-20-79	D	R	0.5	15.5													0	1696
6-20-79	D	R	0.5	15.5	224	1345											1569	3142
6-19-79	D	R*	1.0	13.5													0	91
6-20-79	N	R	0.5	15.3	6666	20000											26666	146666
6-20-79	N	R	0.5	15.3		7016		1169								ES:1169	9354	8187
6-19-79	N	R*	1.0	13.0	50	951	50										1051	150
6-19-79	D	I	0.5	13.0													0	60
6-19-79	D	I*	1.5	13.0	79		79										158	158
6-19-79	N	I	0.5	13.0	173		87										260	0
6-19-79	N	I*	1.5	12.7			56	56									112	0
6-19-79	D	J	0.5	13.0	29			29									58	0
6-19-79	D	J	2.5	13.0	30		31										61	0
6-19-79	D	J*	3.0	13.0													0	465
6-19-79	N	J	0.5	13.6	45		45										90	0
6-19-79	N	J	2.5	12.7		38		76									114	77
6-19-79	N	J*	3.0	12.7		50	101										151	0
6-19-79	D	L	0.5	16.2													0	0
6-19-79	D	L	2.0	16.2	13		13										26	0
6-19-79	D	L	4.0	16.2			30										30	0
6-19-79	D	L	5.5	16.5													0	0
6-19-79	D	L*	6.0	12.5													0	0
6-19-79	N	L	0.5	16.5	16		48										64	0
6-19-79	N	L	2.0	16.0			60	45									105	0
6-19-79	N	L	4.0	16.0				14									14	0
6-19-79	N	L	5.5	16.0			16	32									48	49
6-19-79	N	L*	6.0	12.7	31	31								31			93	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
6-19-79	D	N	0.5	16.0													0	0
6-19-79	D	N	2.5	16.0			20										20	0
6-19-79	D	N	4.5	16.0			18	37									55	0
6-19-79	D	N	6.5	16.0			14		14								28	0
6-19-79	D	N	8.5	16.2	15		15										30	0
6-19-79	D	N*	9.0	12.5										22			22	0
6-19-79	N	N	0.5	16.0	48		65										113	0
6-19-79	N	N	2.5	16.0	88		53										141	0
6-19-79	N	N	4.5	16.0	16		214	32									262	0
6-19-79	N	N	6.5	16.0	30	14	267										311	0
6-19-79	N	N	8.5	16.0	66		293	13		146							518	0
6-19-79	N	N*	9.0	13.2	30	30	270										330	0
6-19-79	D	O	0.5	17.5	15		15										30	0
6-19-79	D	O	3.0	17.5													0	0
6-19-79	D	O	6.0	17.5	63		62	20		20							165	0
6-19-79	D	O	9.0	17.5	51		185	16									252	0
6-19-79	D	O	11.0	15.8			39										39	0
6-19-79	D	O*	12.0	13.0	36												36	0
6-19-79	N	O	0.5	17.1			103	34									137	0
6-19-79	N	O	3.0	16.0			239	15		15							269	0
6-19-79	N	O	6.0	16.0	16		261	65						16			358	0
6-19-79	N	O	9.0	16.0			48										48	0
6-19-79	N	O	11.0	16.0			27										27	0
6-19-79	N	O*	12.0	12.5	33												33	0
6-19-79	D	W	0.5	17.8													0	0
6-19-79	D	W	4.5	15.0	112		66										178	0
6-19-79	D	W	8.5	15.0	40		235	19		19							313	0
6-19-79	D	W	11.5	15.0			58			58							116	0
6-19-79	D	W	14.0	12.0			13										13	0
6-19-79	D	W*	15.0	15.0													0	0
6-19-79	N	W	0.5	16.0			51			34							85	0
6-19-79	N	W	4.5	14.5	13		162										175	0
6-19-79	N	W	8.5	14.5			15										15	0
6-19-79	N	W	11.5	14.5	15		30										45	0
6-19-79	N	W	14.0	13.5			12										12	0
6-19-79	N	W*	15.0	13.3													0	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
7-02-79	D	Q	0.5	11.0	444												444	444
7-02-79	D	Q	0.5	11.0	222												222	222
7-02-79	D	Q*	1.0	11.0	3718	1061	265										5044	83499
7-03-79	N	Q	0.5	9.6	162												162	1463
7-03-79	N	Q	0.5	9.6	649	487											1136	1300
7-03-79	N	Q*	1.0	9.6	1041	347	694										2082	6596
7-02-79	D	R	0.5	12.4	1513												1513	6277
7-02-79	D	R	0.5	12.4	648												648	6493
7-02-79	D	R*	1.0	10.7		46	46										92	924
7-03-79	N	R	0.5	10.0	2757												2757	766
7-03-79	N	R	0.5	10.0	2297	153											2450	766
7-03-79	N	R*	1.0	10.0	113		113										226	5225
7-02-79	D	I	0.5	9.6			33										33	0
7-02-79	D	I*	1.5	7.3	154	77											231	463
7-03-79	N	I	0.5	9.6	338												338	0
7-03-79	N	I*	1.5	8.5	154												154	29226
7-02-79	D	J	0.5	9.3													0	0
7-02-79	D	J	2.5	6.5			52	26								XS: 26	104	0
7-02-79	D	J*	3.0	6.5													0	176
7-03-79	N	J	0.5	9.5	94												94	0
7-03-79	N	J	2.5	7.2	76				74								150	0
7-03-79	N	J*	3.0	7.2					103								103	206
7-03-79	D	L	0.5	11.0													0	0
7-03-79	D	L	2.0	10.0													0	0
7-03-79	D	L	4.0	10.0													0	0
7-03-79	D	L	5.5	10.0	20												20	0
7-02-79	D	L*	6.0	6.1	29												29	0
7-03-79	N	L	0.5	10.0	26												26	0
7-03-79	N	L	2.0	9.0	42			14									56	0
7-03-79	N	L	4.0	9.0	96		31	31	31								189	0
7-03-79	N	L	5.5	9.0	40												40	0
7-03-79	N	L*	6.0	6.6	59												59	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
7-03-79	D	N	0.5	11.0			14										14	0
7-03-79	D	N	2.5	9.0	15												15	0
7-03-79	D	N	4.5	9.0													0	0
7-03-79	D	N	6.5	9.0			21	21									42	0
7-03-79	D	N	8.5	9.2	16												16	0
7-02-79	D	N*	9.0	5.9													0	0
7-03-79	N	N	0.5	10.0	96			65	16								177	0
7-03-79	N	N	2.5	8.3	108			91									199	0
7-03-79	N	N	4.5	8.3				14									14	0
7-03-79	N	N	6.5	8.3													0	0
7-03-79	N	N	8.5	8.0	19												19	0
7-03-79	N	N*	9.0	5.9													0	0
7-03-79	D	O	0.5	10.0													0	0
7-03-79	D	O	3.0	8.0													0	0
7-03-79	D	O	6.0	8.0			18	18									36	0
7-03-79	D	O	9.0	8.0													0	0
7-03-79	D	O	11.0	8.0				49								FS: 16	65	0
7-02-79	D	O*	12.0	5.6													0	0
7-03-79	N	O	0.5	9.5	80		16	64	16								176	0
7-03-79	N	O	3.0	8.0	34			123			17						174	0
7-03-79	N	O	6.0	8.0				18									18	0
7-03-79	N	O	9.0	8.0													0	0
7-03-79	N	O	11.0	8.0	17												17	0
7-03-79	N	O*	12.0	5.8													0	28
7-03-79	D	W	0.5	11.0													0	0
7-03-79	D	W	4.5	8.3	14				14								28	0
7-03-79	D	W	8.5	8.3													0	0
7-03-79	D	W	11.5	8.3	32												32	0
7-03-79	D	W	14.0	8.3													0	0
7-02-79	D	W*	15.0	5.5	17												17	0
7-03-79	N	W	0.5	9.0	81			66	16								163	0
7-03-79	N	W	4.5	7.4			16										16	0
7-03-79	N	W	8.5	7.4			15										15	0
7-03-79	N	W	11.5	7.4													0	0
7-03-79	N	W	14.0	7.4													0	0
7-03-79	N	W*	15.0	5.6													0	327

Appendix 10. Continued.

DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
7-17-79	D	Q	0.5	11.0	5392				215							XM: 431	6038	7551
7-17-79	D	Q	0.5	11.0	5200	236											5436	6619
7-17-79	D	Q*	1.0	8.7	149	3588			448								4185	2408692
7-17-79	N	Q	0.5	10.3	153	766											919	613
7-17-79	N	Q	0.5	10.3	153	1225									153		1531	766
7-18-79	N	Q*	1.0	8.7		255			85								340	0
7-17-79	D	R	0.5	14.5	2002	117											2119	53215
7-17-79	D	R	0.5	14.5	2447	256											2703	116827
7-17-79	D	R*	1.0	14.5	52	1466	52										1570	2324880
7-17-79	N	R	0.5	13.5	2704	4055											6759	1932
7-17-79	N	R	0.5	13.5	1230	2987											4217	1231
7-18-79	N	R*	1.0	11.0		382			191								573	958
7-17-79	D	I	0.5	11.4	1975												1975	1473
7-17-79	D	I*	1.5	11.5	7644	2370											10014	1942999
7-18-79	N	I	0.5	11.7			34										34	1054
7-18-79	N	I*	1.5	8.9	304	152										ES: 38	494	114
7-17-79	D	J	0.5	10.0		28											28	85
7-17-79	D	J	2.5	10.5													0	0
7-17-79	D	J*	3.0	10.5													0	0
7-18-79	N	J	0.5	11.8	56												56	0
7-18-79	N	J	2.5	7.9	42												42	0
7-18-79	N	J*	3.0	7.9													0	0
7-19-79	D	L	0.5	12.0	43				14								57	29
7-19-79	D	L	2.0	10.0	14												14	0
7-19-79	D	L	4.0	10.0													0	0
7-19-79	D	L	5.5	9.0													0	0
7-17-79	D	L*	6.0	8.0													0	33
7-19-79	N	L	0.5	11.5				12									12	0
7-19-79	N	L	2.0	11.0													0	0
7-19-79	N	L	4.0	11.0													0	0
7-19-79	N	L	5.5	10.5													0	0
7-18-79	N	L*	6.0	6.5				74								NS: 37	111	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
7-19-79	D	N	0.5	11.0													0	0
7-19-79	D	N	2.5	7.2	13												13	0
7-19-79	D	N	4.5	7.2	14												14	0
7-19-79	D	N	6.5	7.2													0	0
7-19-79	D	N	8.5	6.3													0	0
7-17-79	D	N*	9.0	8.8	30												30	0
7-19-79	N	N	0.5	11.0													0	0
7-19-79	N	N	2.5	9.2				13									13	0
7-19-79	N	N	4.5	9.2													0	0
7-19-79	N	N	6.5	9.2													0	0
7-19-79	N	N	8.5	5.0				13									13	0
7-18-79	N	N*	9.0	5.5													0	0
7-19-79	D	O	0.5	12.0													0	0
7-19-79	D	O	3.0	6.3													0	0
7-19-79	D	O	6.0	6.3													0	0
7-19-79	D	O	9.0	6.3													0	0
7-19-79	D	O	11.0	6.0													0	0
7-17-79	D	O*	12.0	10.0													0	0
7-19-79	N	O	0.5	10.0				13									13	0
7-19-79	N	O	3.0	6.0													0	0
7-19-79	N	O	6.0	6.0	12												12	0
7-19-79	N	O	9.0	6.0							13						13	0
7-19-79	N	O	11.0	4.0													0	0
7-18-79	N	O*	12.0	5.4							30						30	0
7-19-79	D	W	0.5	11.5													0	0
7-19-79	D	W	4.5	4.5	14												14	0
7-19-79	D	W	8.5	4.5													0	0
7-19-79	D	W	11.5	4.5													0	0
7-19-79	D	W	14.0	4.5													0	0
7-17-79	D	W*	15.0	6.3													0	0
7-19-79	N	W	0.5	10.2													0	0
7-19-79	N	W	4.5	4.5			12										12	0
7-19-79	N	W	8.5	4.5													0	0
7-19-79	N	W	11.5	4.5													0	0
7-19-79	N	W	14.0	4.0													0	0
7-18-79	N	W*	15.0	4.7												NS: 27	27	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
8-01-79	D	Q	0.5	14.2	933	233											1166	0
8-01-79	D	Q	0.5	14.2	9742	5126				256						XM: 256	15380	1282
8-01-79	D	Q*	1.0	13.9	3885	22801			777								27463	177797
8-01-79	N	Q	0.5	14.7	1650	3916											5566	206
8-01-79	N	Q	0.5	14.7	1240	2325											3565	0
8-01-79	N	Q*	1.0	14.7	261	7354		87	262							ES: 87 XM: 87	8138	1840
8-01-79	D	R	0.5	15.8	15592	610			305								16507	305
8-01-79	D	R	0.5	15.8	5602				193								5795	386
8-01-79	D	R*	1.0	14.7	4796	11990											16786	547693
8-01-79	N	R	0.5	16.5	4515	7740			215								12470	7741
8-02-79	N	R	0.5	16.5	360	6124											6484	2162
8-01-79	N	R*	1.0	15.5	903	652											1555	181
8-01-79	D	I	0.5	14.3	240												240	0
8-01-79	D	I*	1.5	13.4	1184	32048			1780			296					35308	1991549
8-01-79	N	I	0.5	16.3	3097	3357											6454	0
8-01-79	N	I*	1.5	14.5	1452	2904											4356	1198538
8-01-79	D	J	0.5	14.0	119												119	0
8-01-79	D	J	2.5	12.5		50											50	0
8-01-79	D	J*	3.0	12.5		831						277					1108	53764
8-01-79	N	J	0.5	16.3	861												861	0
8-01-79	N	J	2.5	14.0	215												215	0
8-01-79	N	J*	3.0	14.0													0	14540
8-02-79	D	L	0.5	16.0	262				17								279	0
8-02-79	D	L	2.0	11.3	32												32	0
8-02-79	D	L	4.0	11.3	20												20	0
8-02-79	D	L	5.5	11.2	40												40	0
8-01-79	D	L*	6.0	10.9													0	160
8-02-79	N	L	0.5	16.8	105												105	0
8-02-79	N	L	2.0	11.4	80												80	0
8-02-79	N	L	4.0	11.4	61												61	0
8-02-79	N	L	5.5	11.2													0	0
8-01-79	N	L*	6.0	13.5	50								152				202	305

Appendix 10. Continued.

DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
8-02-79	D	N	0.5	15.2	474												474	0
8-02-79	D	N	2.5	10.3	16												16	0
8-02-79	D	N	4.5	10.3	13												13	0
8-02-79	D	N	6.5	10.3	42												42	0
8-02-79	D	N	8.5	10.0													0	0
8-01-79	D	N*	9.0	15.3	72												72	0
8-02-79	N	N	0.5	15.5	60	15											75	0
8-02-79	N	N	2.5	10.0	16												16	0
8-02-79	N	N	4.5	10.0	60												60	0
8-02-79	N	N	6.5	10.0	52												52	0
8-02-79	N	N	8.5	8.5													0	0
8-01-79	N	N*	9.0	9.2		107											107	268
8-02-79	D	O	0.5	15.0													0	0
8-02-79	D	O	3.0	6.8	16												16	0
8-02-79	D	O	6.0	6.8													0	0
8-02-79	D	O	9.0	6.8	18												18	0
8-02-79	D	O	11.0	6.3													0	0
8-01-79	D	O*	12.0	14.2	49												49	49
8-02-79	N	O	0.5	15.3	26					26							52	0
8-02-79	N	O	3.0	13.6	99												99	0
8-02-79	N	O	6.0	13.6	94												94	0
8-02-79	N	O	9.0	13.6	96												96	0
8-02-79	N	O	11.0	6.2													0	0
8-01-79	N	O*	12.0	6.8							167						167	0
8-02-79	D	W	0.5	15.0	16												16	0
8-02-79	D	W	4.5	7.0	42												42	0
8-02-79	D	W	8.5	7.0													0	0
8-02-79	D	W	11.5	7.0													0	0
8-02-79	D	W	14.0	5.5	16												16	0
8-01-79	D	W*	15.0	9.3	37												37	0
8-02-79	N	W	0.5	16.0	99											ES: 14	113	0
8-02-79	N	W	4.5	12.5	274												274	0
8-02-79	N	W	8.5	12.5	144												144	0
8-02-79	N	W	11.5	12.5	58		14										72	0
8-02-79	N	W	14.0	7.5	54						18						72	0
8-01-79	N	W*	15.0	8.0							34						34	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
8-20-79	D	Q	0.5	15.0													0	0
8-20-79	D	Q	0.5	15.0													0	0
8-21-79	D	Q*	1.0	16.0	364												364	0
8-20-79	N	Q	0.5	15.0	177												177	0
8-20-79	N	Q	0.5	15.0	216												216	0
8-22-79	N	Q*	1.0	15.2	1978	86											2064	0
8-20-79	D	R	0.5	14.5	136												136	0
8-20-79	D	R	0.5	14.5	363												363	0
8-21-79	D	R*	1.0	16.0	1346												1346	0
8-20-79	N	R	0.5	16.0	573												573	0
8-20-79	N	R	0.5	16.0	244	244											488	0
8-22-79	N	R*	1.0	15.5	153	495											648	0
8-21-79	D	I	0.5	16.5	26												26	0
8-21-79	D	I*	1.5	16.0	2484												2484	0
8-22-79	N	I	0.5	15.8	673												673	0
8-22-79	N	I*	1.5	15.3	224												224	0
8-21-79	D	J	0.5	16.0	29												29	0
8-21-79	D	J	2.5	15.3	831												831	0
8-21-79	D	J*	3.0	15.3													0	0
8-22-79	N	J	0.5	15.7	620												620	0
8-22-79	N	J	2.5	15.0	290												290	0
8-22-79	N	J*	3.0	15.0	210	70									140		420	0
8-21-79	D	L	0.5	16.0	112												112	0
8-21-79	D	L	2.0	15.2	84												84	0
8-21-79	D	L	4.0	15.2	546												546	0
8-21-79	D	L	5.5	15.5	402												402	0
8-21-79	D	L*	6.0	14.9	20												20	0
8-21-79	N	L	0.5	16.0	301	12											313	0
8-21-79	N	L	2.0	15.0	178												178	0
8-21-79	N	L	4.0	15.0	90												90	0
8-21-79	N	L	5.5	15.0	105												105	0
8-22-79	N	L*	6.0	15.2											54	NS: 54	108	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
8-21-79	D	N	0.5	15.4	91												91	0
8-21-79	D	N	2.5	14.9	779											XC: 13	792	0
8-21-79	D	N	4.5	14.9	300												300	0
8-21-79	D	N	6.5	14.9	294												294	0
8-21-79	D	N	8.5	14.9	113												113	0
8-21-79	D	N*	9.0	15.2													0	0
8-21-79	N	N	0.5	15.1	298	13											311	0
8-21-79	N	N	2.5	14.3	707				13								720	0
8-21-79	N	N	4.5	14.3	130												130	0
8-21-79	N	N	6.5	14.3	72	12											84	0
8-21-79	N	N	8.5	14.3	162												162	0
8-22-79	N	N*	9.0	15.0	32												32	0
8-21-79	D	O	0.5	15.4													0	0
8-21-79	D	O	3.0	14.9	84												84	0
8-21-79	D	O	6.0	14.9	215												215	0
8-21-79	D	O	9.0	14.9	16												16	0
8-21-79	D	O	11.0	14.9	51												51	0
8-21-79	D	O*	12.0	14.5													0	0
8-21-79	N	O	0.5	15.0	908	12											920	0
8-21-79	N	O	3.0	14.8	585				26								611	0
8-21-79	N	O	6.0	14.8	712				33								745	0
8-21-79	N	O	9.0	14.8	576												576	0
8-21-79	N	O	11.0	14.5	696			11									707	0
8-22-79	N	O*	12.0	15.0	84												84	0
8-21-79	D	W	0.5	15.2													0	0
8-21-79	D	W	4.5	14.5	313												313	0
8-21-79	D	W	8.5	14.5	66												66	0
8-21-79	D	W	11.5	14.5	51			16									67	0
8-21-79	D	W	14.0	14.5	17												17	0
8-21-79	D	W*	15.0	15.5													0	0
8-21-79	N	W	0.5	15.0	803												803	0
8-21-79	N	W	4.5	15.0	183												183	0
8-21-79	N	W	8.5	15.0	406												406	0
8-21-79	N	W	11.5	15.0	369												369	0
8-21-79	N	W	14.0	14.6	406												406	0
8-22-79	N	W*	15.0	15.5	233												233	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
9-19-79	D	Q	0.5	14.8													0	0
9-19-79	D	Q	0.5	14.8													0	0
9-19-79	D	Q*	1.0	12.7	170												170	34
9-19-79	N	Q	0.5	16.0	248												248	0
9-19-79	N	Q	0.5	16.0	242												242	0
9-19-79	N	Q*	1.0	14.0	349												349	0
9-19-79	D	R	0.5	14.5													0	0
9-19-79	D	R	0.5	14.5													0	0
9-19-79	D	R*	1.0	14.5	1445												1445	0
9-19-79	N	R	0.5	15.5													0	0
9-19-79	N	R	0.5	15.5													0	0
9-19-79	N	R*	1.0	13.7	140												140	0
9-19-79	D	I	0.5	12.9													0	0
9-19-79	D	I*	1.5	12.7	76												76	0
9-19-79	N	I	0.5	13.7	708												708	0
9-19-79	N	I*	1.5	13.7													0	0
9-19-79	D	J	0.5	13.5													0	0
9-19-79	D	J	2.5	12.5													0	0
9-19-79	D	J*	3.0	12.5	150												150	0
9-19-79	N	J	0.5	15.0	732												732	0
9-19-79	N	J	2.5	13.2													0	0
9-19-79	N	J*	3.0	13.2	75								75				150	0
9-19-79	D	L	0.5	12.7	15												15	0
9-19-79	D	L	2.0	11.7	34												34	0
9-19-79	D	L	4.0	11.7	42												42	0
9-19-79	D	L	5.5	11.7	56												56	0
9-19-79	D	L*	6.0	11.7													0	0
9-19-79	N	L	0.5	12.2	15												15	0
9-19-79	N	L	2.0	13.0	84												84	0
9-19-79	N	L	4.0	13.0	28												28	0
9-19-79	N	L	5.5	12.8	75												75	0
9-19-79	N	L*	6.0	11.1													0	0

Appendix 10. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
9-19-79	D	N	0.5	13.3													0	0
9-19-79	D	N	2.5	13.3	45												45	0
9-19-79	D	N	4.5	13.3	14												14	0
9-19-79	D	N	6.5	13.3	26												26	0
9-19-79	D	N	8.5	11.7	17												17	0
9-19-79	D	N*	9.0	10.1													0	0
9-19-79	N	N	0.5	13.5													0	0
9-19-79	N	N	2.5	12.8													0	0
9-19-79	N	N	4.5	12.8	15												15	0
9-19-79	N	N	6.5	12.8													0	0
9-19-79	N	N	8.5	12.5	75												75	0
9-19-79	N	N*	9.0	11.7									45				45	0
9-19-79	D	O	0.5	13.9	14												14	0
9-19-79	D	O	3.0	13.1	45												45	0
9-19-79	D	O	6.0	13.1	45												45	0
9-19-79	D	O	9.0	13.1	22				11								33	0
9-19-79	D	O	11.0	10.9													0	0
9-19-79	D	O*	12.0	10.0													0	0
9-19-79	N	O	0.5	13.6	14												14	0
9-19-79	N	O	3.0	13.6													0	0
9-19-79	N	O	6.0	13.6													0	0
9-19-79	N	O	9.0	13.6	13												13	0
9-19-79	N	O	11.0	11.5	13												13	0
9-19-79	N	O*	12.0	10.9									35				35	0
9-19-79	D	W	0.5	13.5													0	0
9-19-79	D	W	4.5	12.4	48												48	0
9-19-79	D	W	8.5	12.4	64												64	0
9-19-79	D	W	11.5	12.4													0	0
9-19-79	D	W	14.0	10.1													0	0
9-19-79	D	W*	15.0	9.1													0	0
9-19-79	N	W	0.5	14.2	15												15	0
9-19-79	N	W	4.5	13.1	14												14	0
9-19-79	N	W	8.5	13.1													0	0
9-19-79	N	W	11.5	13.1													0	0
9-19-79	N	W	14.0	10.5													0	0
9-19-79	N	W*	15.0	10.1									32				32	0

APPENDIX 11

Appendix 11. Number of fish larvae and eggs per 1000 m^3 for south transect stations in Lake Michigan (Fig. 1) near the J. H. Campbell Plant, eastern Lake Michigan, April to September 1979. D = day, N = night, * = sled tow. See Table 42 for species code identification.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
4-18-79	D	E	0.5	10.0													0	0
4-18-79	D	E	0.5	10.0													0	0
4-17-79	D	E*	1.0	7.4													0	0
4-18-79	N	E	0.5	8.3													0	0
4-18-79	N	E	0.5	8.3									202				202	0
4-16-79	N	E*	1.0	7.4													0	0
4-17-79	D	A	0.5	8.4													0	0
4-17-79	D	A*	1.5	8.4													0	0
4-16-79	N	A	0.5	7.0													0	0
4-16-79	N	A*	1.5	7.0													0	0
4-17-79	D	B	0.5	7.8													0	0
4-17-79	D	B	2.5	7.8													0	0
4-17-79	D	B*	3.0	7.8													0	0
4-16-79	N	B	0.5	7.5													0	0
4-16-79	N	B	2.5	7.5													0	0
4-16-79	N	B*	3.0	7.5													0	0
4-16-79	D	C	0.5	4.6													0	0
4-16-79	D	C	2.0	4.6													0	0
4-16-79	D	C	4.0	4.6													0	0
4-16-79	D	C	5.5	4.6													0	0
4-17-79	D	C*	6.0	4.6													0	0
4-16-79	N	C	0.5	5.0													0	0
4-16-79	N	C	2.0	5.0													0	0
4-16-79	N	C	4.0	5.0													0	0
4-16-79	N	C	5.5	4.6													0	0
4-17-79	N	C*	6.0	4.6													0	0
4-16-79	D	D	0.5	2.5													0	0
4-16-79	D	D	2.5	3.0													0	0
4-16-79	D	D	4.5	3.0													0	0
4-16-79	D	D	6.5	3.0									20				20	0
4-16-79	D	D	8.5	3.0													0	0
4-17-79	D	D*	9.0	3.0													0	0
4-16-79	N	D	0.5	2.0													0	0
4-16-79	N	D	2.5	2.0													0	0
4-16-79	N	D	4.5	2.0													0	0
4-16-79	N	D	6.5	2.0													0	0
4-16-79	N	D	8.5	2.0													0	0
4-17-79	N	D*	9.0	2.0													0	0

Appendix 11. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
4-16-79	D	E	0.5	2.5													0	0
4-16-79	D	E	3.0	2.5													0	0
4-16-79	D	E	6.0	2.5													0	0
4-16-79	D	E	9.0	2.5													0	0
4-16-79	D	E	11.0	3.0													0	0
4-17-79	D	E*	12.0	3.0													0	0
4-16-79	N	E	0.5	2.5													0	0
4-16-79	N	E	3.0	2.5													0	0
4-16-79	N	E	6.0	2.5													0	0
4-16-79	N	E	9.0	2.5													0	0
4-16-79	N	E	11.0	2.5													0	0
4-16-79	N	E*	12.0	2.5													0	0
4-16-79	D	F	0.5	2.5													0	0
4-16-79	D	F	4.5	2.5													0	0
4-16-79	D	F	8.5	2.5												FS: 22	22	0
4-16-79	D	F	11.5	2.5													0	0
4-16-79	D	F	14.0	2.5													0	0
4-17-79	D	F*	15.0	2.5													0	0
4-16-79	N	F	0.5	2.5													0	0
4-16-79	N	F	4.5	2.5												FS: 16	16	0
4-16-79	N	F	8.5	2.5													0	0
4-16-79	N	F	11.5	2.5													0	0
4-16-79	N	F	14.0	3.0													0	0
4-17-79	N	F*	15.0	3.0													0	0
5-14-79	D	P	0.5	13.5				637	318								955	0
5-14-79	D	P	0.5	13.5				2067									2067	0
5-15-79	D	P*	1.0	13.8				21				21					42	0
5-14-79	N	P	0.5	13.5												PM: 149	149	0
5-14-79	N	P	0.5	13.5													0	0
5-16-79	N	P*	1.0	13.0				219									219	0
5-15-79	D	A	0.5	13.0													0	0
5-15-79	D	A*	1.5	13.8				1495								XC: 57	1552	0
5-16-79	N	A	0.5	13.0				87									87	0
5-16-79	N	A*	1.5	13.0				118	39								157	0

Appendix 11. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
5-15-79	D	B	0.5	12.6													0	0
5-15-79	D	B	2.5	12.3			21	43									64	0
5-15-79	D	B*	3.0	13.4				63	63			63					189	0
5-16-79	N	B	0.5	13.0													0	0
5-16-79	N	B	2.5	11.5				114									114	0
5-16-79	N	B*	3.0	12.0				65									65	0
5-15-79	D	C	0.5	13.0			14										14	0
5-15-79	D	C	2.0	12.8				21	21	129							171	0
5-15-79	D	C	4.0	12.8													0	0
5-15-79	D	C	5.5	12.5						65							65	0
5-15-79	D	C*	6.0	13.4			28		57	28							113	0
5-15-79	N	C	0.5	11.0			36										36	0
5-15-79	N	C	2.0	10.0			17	17									34	0
5-15-79	N	C	4.0	10.0													0	0
5-15-79	N	C	5.5	10.0													0	0
5-16-79	N	C*	6.0	12.0													0	0
5-15-79	D	D	0.5	13.0					19	135							154	0
5-15-79	D	D	2.5	11.5						71							71	0
5-15-79	D	D	4.5	11.5			65			32							97	0
5-15-79	D	D	6.5	11.5													0	0
5-15-79	D	D	8.5	11.2						54							54	0
5-15-79	D	D*	9.0	11.9													0	0
5-15-79	N	D	0.5	11.2			15										15	0
5-15-79	N	D	2.5	9.5					16					16			32	0
5-15-79	N	D	4.5	9.5													0	0
5-15-79	N	D	6.5	9.5												PM: 16	16	0
5-15-79	N	D	8.5	9.5			19										19	0
5-16-79	N	D*	9.0	11.0													0	0
5-15-79	D	E	0.5	13.0													0	0
5-15-79	D	E	3.0	11.5													0	0
5-15-79	D	E	6.0	11.5			18			18							36	0
5-15-79	D	E	9.0	11.5													0	0
5-15-79	D	E	11.0	11.0													0	0
5-15-79	D	E*	12.0	11.0						127							127	0
5-15-79	N	E	0.5	10.8						14							14	0
5-15-79	N	E	3.0	9.6													0	0
5-15-79	N	E	6.0	9.6			16										16	0
5-15-79	N	E	9.0	9.6													0	0
5-15-79	N	E	11.0	9.0													0	0

Appendix 11. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
5-15-79	D	F	0.5	12.0													0	0
5-15-79	D	F	4.5	11.8													0	0
5-15-79	D	F	8.5	11.8										30			30	0
5-15-79	D	F	11.5	11.8													0	0
5-15-79	D	F	14.0	11.5													0	0
5-15-79	D	F*	15.0	11.0													0	0
5-15-79	N	F	0.5	11.2	15												15	0
5-15-79	N	F	4.5	8.2	61												61	0
5-15-79	N	F	8.5	8.2			19									FS: 19	38	0
5-15-79	N	F	14.0	8.0													0	0
5-16-79	N	F*	15.0	10.0													0	0
6-05-79	D	P	0.5	13.5													0	0
6-05-79	D	P	0.5	13.5													0	0
6-05-79	D	P*	1.0	12.0													0	681
6-05-79	N	P	0.5	13.5													0	0
6-05-79	N	P	0.5	13.5													0	0
6-04-79	N	P*	1.0	13.5													0	0
6-05-79	D	A	0.5	13.5													0	0
6-05-79	D	A*	1.5	12.0				76									76	0
6-04-79	N	A	0.5	14.0													0	0
6-04-79	N	A*	1.5	14.0													0	0
6-05-79	D	B	0.5	12.5													0	0
6-05-79	D	B	2.5	11.3					77								77	0
6-05-79	D	B*	3.0	11.3													0	82
6-04-79	N	B	0.5	13.5													0	0
6-04-79	N	B	2.5	12.5													0	0
6-04-79	N	B*	3.0	12.5													0	0
6-05-79	D	C	0.5	11.0													0	0
6-05-79	D	C	2.0	10.9													0	0
6-05-79	D	C	4.0	10.9			14										14	0
6-05-79	D	C	5.5	10.9			14										14	0
6-05-79	D	C*	6.0	10.5													0	0
6-05-79	N	C	0.5	10.0			18										18	0
6-05-79	N	C	2.0	10.0													0	19
6-05-79	N	C	4.0	10.0			13										13	0
6-05-79	N	C	5.5	10.5													0	181
6-04-79	N	C*	6.0	11.5													0	0

Appendix 11. Continued.

DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BB	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
6-05-79	D	D	0.5	11.5													0	0
6-05-79	D	D	2.5	10.5													0	0
6-05-79	D	D	4.5	10.5													0	0
6-05-79	D	D	6.5	10.5			25										25	0
6-05-79	D	D	8.5	10.2													0	0
6-05-79	D	D*	9.0	10.0													0	0
6-05-79	N	D	0.5	10.5													0	0
6-05-79	N	D	2.5	9.8													0	0
6-05-79	N	D	4.5	9.8	17		69										86	0
6-05-79	N	D	6.5	9.8			43										43	0
6-05-79	N	D	8.5	9.8													0	0
6-04-79	N	D*	9.0	10.8			116										116	0
6-05-79	D	E	0.5	11.8													0	0
6-05-79	D	E	3.0	10.5													0	0
6-05-79	D	E	6.0	10.5													0	0
6-05-79	D	E	9.0	10.5													0	0
6-05-79	D	E	11.0	10.5			12										12	0
6-05-79	D	E*	12.0	10.0													0	0
6-05-79	N	E	0.5	11.0													0	0
6-05-79	N	E	3.0	10.2			34										34	0
6-05-79	N	E	6.0	10.2													0	0
6-05-79	N	E	9.0	10.2			24										24	0
6-05-79	N	E	11.0	9.0			15										15	0
6-04-79	N	E*	12.0	10.5													0	0
6-05-79	D	F	0.5	11.5													0	0
6-05-79	D	F	4.5	10.0			30										30	0
6-05-79	D	F	8.5	10.0													0	0
6-05-79	D	F	11.5	10.0													0	0
6-05-79	D	F	14.0	9.5													0	0
6-05-79	D	F*	15.0	9.8													0	0
6-05-79	N	F	0.5	10.5													0	0
6-05-79	N	F	4.5	9.0			18										18	0
6-05-79	N	F	8.5	9.0			16										16	0
6-05-79	N	F	11.5	9.0	14												14	14
6-05-79	N	F	14.0	9.0												PM: 13	13	0
6-04-79	N	F*	15.0	9.8													0	0

Appendix 11. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
6-20-79	D	P	0.5	16.5		132		132									264	1984
6-20-79	D	P	0.5	16.5	360	360											720	1981
6-19-79	D	P*	1.0	13.5	164	410											574	10022
6-20-79	N	P	0.5	16.0													0	2298
6-20-79	N	P	0.5	16.0	888												888	0
6-20-79	N	P*	1.0	13.5		352	88										440	10066
6-19-79	D	A	0.5	11.4			22							22			44	17326
6-19-79	D	A*	1.5	11.7		4600			4600								9200	16837632
6-20-79	N	A	0.5	13.0		100	50										150	100
6-19-79	N	A*	1.5	13.0													0	3444
6-19-79	D	B	0.5	13.9													0	217
6-19-79	D	B	2.5	12.3										48			48	0
6-19-79	D	B*	3.0	12.3													0	7931
6-20-79	N	B	0.5	13.0			57										57	0
6-20-79	N	B	2.5	13.0	37		75										112	152
6-19-79	N	B*	3.0	13.0		57											57	1793
6-18-79	D	C	0.5	15.5													0	0
6-18-79	D	C	2.0	15.0													0	0
6-18-79	D	C	4.0	15.0			37										37	0
6-18-79	D	C	5.5	15.0	14			14									28	0
6-19-79	D	C*	6.0	11.3				23									23	23
6-18-79	N	C	0.5	15.0			18										18	0
6-18-79	N	C	2.0	15.0													0	0
6-18-79	N	C	4.0	15.0			14										14	0
6-18-79	N	C	5.5	15.0													0	0
6-20-79	N	C*	6.0	14.5			111	27									138	55
6-18-79	D	D	0.5	16.0													0	0
6-18-79	D	D	2.5	16.0													0	0
6-18-79	D	D	4.5	16.0	15		30										45	0
6-18-79	D	D	6.5	16.0			18										18	0
6-18-79	D	D	8.5	16.0			28										28	0
6-19-79	D	D*	9.0	9.0	48		24										72	0
6-18-79	N	D	0.5	15.0	15												15	0
6-18-79	N	D	2.5	14.5													0	0
6-18-79	N	D	4.5	14.5			14										14	0
6-18-79	N	D	6.5	14.5	16		16										32	0
6-18-79	N	D	8.5	14.0			13										13	0
6-20-79	N	D*	9.0	11.9	84		143	28									255	0

Appendix 11. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
6-18-79	D	E	0.5	15.2													0	0
6-18-79	D	E	3.0	15.0													0	0
6-18-79	D	E	6.0	15.0			235										235	0
6-18-79	D	E	9.0	15.0	15		29										44	0
6-18-79	D	E	11.0	15.0	22		22										44	0
6-19-79	D	E*	12.0	7.5													0	0
6-18-79	N	E	0.5	14.5			17										17	0
6-18-79	N	E	3.0	12.2				14									14	0
6-18-79	N	E	6.0	12.2													0	0
6-18-79	N	E	9.0	12.2			13										13	0
6-18-79	N	E	11.0	12.0													0	0
6-19-79	N	E*	12.0	11.7	50		406										456	0
6-18-79	D	F	0.5	15.5												ES: 16	16	0
6-18-79	D	F	4.5	15.0	74		485										559	0
6-18-79	D	F	8.5	15.0	15		31										46	0
6-18-79	D	F	11.5	15.0													0	0
6-18-79	D	F	14.0	15.0			14										14	0
6-19-79	D	F*	15.0	7.5	27		190										217	0
6-18-79	N	F	0.5	15.0			29										29	0
6-18-79	N	F	4.5	15.0			43										43	0
6-18-79	N	F	8.5	15.0			11										11	0
6-18-79	N	F	11.5	15.0			16							16			32	0
6-18-79	N	F	14.0	12.0													0	0
6-19-79	N	F*	15.0	11.5			79										79	0
7-02-79	D	P	0.5	12.7	1075												1075	215
7-02-79	D	P	0.5	12.7	645												645	0
7-02-79	D	P*	1.0	11.2												XM: 296	296	2077
7-03-79	N	P	0.5	10.0	680												680	0
7-03-79	N	P	0.5	10.0	680												680	136
7-03-79	N	P*	1.0	10.0													0	0
7-02-79	D	A	0.5	11.0													0	0
7-02-79	D	A*	1.5	8.4	296												296	0
7-02-79	N	A	0.5	9.5	336												336	0
7-03-79	N	A*	1.5	8.0													0	0

Appendix 11. Continued.

DATE	DIEL PERIOD	STA- TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
7-02-79	D	B	0.5	9.9													0	0
7-02-79	D	B	2.5	7.5	603												603	0
7-02-79	D	B*	3.0	7.5	77												77	0
7-02-79	N	B	0.5	9.5	125				31								156	0
7-02-79	N	B	2.5	7.5	126												126	0
7-02-79	N	B*	3.0	7.5													0	375
7-02-79	D	C	0.5	9.5													0	0
7-02-79	D	C	2.0	7.0	20		81	20								XM: 20	141	0
7-02-79	D	C	4.0	7.0	15		47										62	0
7-02-79	D	C	5.5	7.0												XM: 17	17	0
7-02-79	D	C*	6.0	6.5	897			34	34								965	0
7-02-79	N	C	0.5	8.5	24		12										36	0
7-02-79	N	C	2.0	6.0													0	0
7-02-79	N	C	4.0	6.0	40												40	0
7-02-79	N	C	5.5	6.0			19										19	0
7-02-79	N	C*	6.0	6.5	161												161	0
7-02-79	D	D	0.5	10.0													0	0
7-02-79	D	D	2.5	7.0	19												19	19
7-02-79	D	D	4.5	7.0													0	0
7-02-79	D	D	6.5	7.0	16		32										48	0
7-02-79	D	D	8.5	7.0					15								15	0
7-02-79	D	D*	9.0	6.0	126												126	42
7-02-79	N	D	0.5	9.0													0	0
7-02-79	N	D	2.5	5.0	16												16	0
7-02-79	N	D	4.5	5.0			17										17	0
7-02-79	N	D	6.5	5.0			14										14	0
7-02-79	N	D	8.5	5.0												FS: 18	18	0
7-02-79	N	D*	9.0	6.0							42						42	126
7-02-79	D	E	0.5	10.0													0	0
7-02-79	D	E	3.0	7.4													0	0
7-02-79	D	E	6.0	7.4				23									23	0
7-02-79	D	E	9.0	7.4	44												44	0
7-02-79	D	E	11.0	6.5													0	0
7-02-79	D	E*	12.0	5.9	79												79	0
7-02-79	N	E	0.5	9.0													0	0
7-02-79	N	E	3.0	5.0			17										17	0
7-02-79	N	E	6.0	5.0				14									14	0
7-02-79	N	E	9.0	5.0			35										35	0
7-02-79	N	E	11.0	5.0													0	0
7-02-79	N	E*	12.0	5.7	40						40						80	80

Appendix 11. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
7-02-79	D	F	0.5	9.9													0	0
7-02-79	D	F	4.5	7.0													0	0
7-02-79	D	F	8.5	7.0													0	0
7-02-79	D	F	11.5	7.0				18									18	0
7-02-79	D	F	14.0	6.9													0	0
7-02-79	D	F*	15.0	5.9													0	0
7-02-79	N	F	0.5	9.0													0	0
7-02-79	N	F	4.5	6.0			17	71									88	0
7-02-79	N	F	8.5	6.0													0	0
7-02-79	N	F	11.5	6.0													0	0
7-02-79	N	F	14.0	6.0												XC: 16	16	0
7-02-79	N	F*	15.0	5.5												NS: 19	19	0
7-17-79	D	P	0.5	13.0	685	549											1234	687
7-17-79	D	P	0.5	13.0	1369	456											1825	7762
7-17-79	D	P*	1.0	13.0	321	571											892	10494
7-17-79	N	P	0.5	11.0	45	502											547	0
7-17-79	N	P	0.5	11.0		2144											2144	0
7-18-79	N	P*	1.0	10.3		1998											1998	307
7-17-79	D	A	0.5	13.0	57												57	0
7-17-79	D	A*	1.5	9.4	427	142			71								640	11394
7-18-79	N	A	0.5	13.0													0	0
7-18-79	N	A*	1.5	9.4													0	0
7-17-79	D	B	0.5	10.1				15									15	0
7-17-79	D	B	2.5	7.8	17												17	0
7-17-79	D	B*	3.0	7.8	194	194											388	9726
7-18-79	N	B	0.5	12.0		66											66	0
7-18-79	N	B	2.5	7.3													0	0
7-18-79	N	B*	3.0	7.3													0	0
7-17-79	D	C	0.5	9.5													0	0
7-17-79	D	C	2.0	5.0													0	0
7-17-79	D	C	4.0	5.0													0	0
7-17-79	D	C	5.5	5.0				12									12	0
7-17-79	D	C*	6.0	6.2	75												75	305
7-18-79	N	C	0.5	8.0													0	0
7-18-79	N	C	2.0	4.0													0	0
7-18-79	N	C	4.0	4.0													0	0
7-18-79	N	C	5.5	4.0													0	0
7-18-79	N	C*	6.0	4.0													0	0

Appendix 11. Continued.

DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
7-18-79	D	D	0.5	10.0													0	0
7-18-79	D	D	2.5	4.0			14										14	0
7-18-79	D	D	4.5	4.0													0	0
7-18-79	D	D	6.5	4.0													0	0
7-18-79	D	D	8.5	4.5													0	0
7-17-79	D	D*	9.0	6.1	115												115	38
7-18-79	N	D	0.5	7.0													0	0
7-18-79	N	D	2.5	4.0													0	0
7-18-79	N	D	4.5	4.0													0	0
7-18-79	N	D	6.5	4.0													0	0
7-18-79	N	D	8.5	4.0													0	0
7-18-79	N	D*	9.0	4.0													0	0
7-18-79	D	E	0.5	8.5													0	0
7-18-79	D	E	3.0	4.0													0	0
7-18-79	D	E	6.0	4.0													0	0
7-18-79	D	E	9.0	4.0													0	0
7-18-79	D	E	11.0	4.0													0	0
7-17-79	D	E*	12.0	5.8	57												57	114
7-18-79	N	E	0.5	8.0													0	0
7-18-79	N	E	3.0	4.0													0	0
7-18-79	N	E	6.0	4.0	18												18	0
7-18-79	N	E	9.0	4.0													0	0
7-18-79	N	E	11.0	4.0							15						15	0
7-18-79	N	E*	12.0	4.0													0	0
7-18-79	D	F	0.5	9.0													0	32
7-18-79	D	F	4.5	4.0	23												23	0
7-18-79	D	F	8.5	4.0													0	0
7-18-79	D	F	11.5	4.0													0	0
7-18-79	D	F	14.0	4.0												FS: 14	14	0
7-17-79	D	F*	15.0	5.4	294												294	168
7-18-79	N	F	0.5	6.5													0	0
7-18-79	N	F	4.5	4.0													0	0
7-18-79	N	F	8.5	4.0													0	0
7-18-79	N	F	11.5	4.0													0	0
7-18-79	N	F	14.0	4.0													0	0
7-18-79	N	F*	15.0	4.0							130						130	0

Appendix 11. Continued.

DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
8-01-79	D	P	0.5	14.5	2132												2132	533
8-01-79	D	P	0.5	14.5	579												579	0
8-01-79	D	P*	1.0	13.0	4416	15456			368								20240	47108
8-02-79	N	P	0.5	15.2	2121	25150											27271	2121
8-02-79	N	P	0.5	15.2	1900	15392											17292	1587
8-01-79	N	P*	1.0	15.2	724	23											747	23
8-01-79	D	A	0.5	14.5	130												130	0
8-01-79	D	A*	1.5	14.0	552												552	10489
8-01-79	N	A	0.5	15.2	1024	146											1170	0
8-01-79	N	A*	1.5	14.3	33	66											99	3011
8-01-79	D	B	0.5	14.5	17												17	0
8-01-79	D	B	2.5	12.0	85												85	0
8-01-79	D	B*	3.0	12.0													0	0
8-01-79	N	B	0.5	15.0	240	16											256	0
8-01-79	N	B	2.5	13.5	412	123											535	0
8-01-79	N	B*	3.0	13.5		47											47	660
8-01-79	D	C	0.5	14.3	1803												1803	0
8-01-79	D	C	2.0	13.0	204												204	0
8-01-79	D	C	4.0	13.0	152												152	0
8-01-79	D	C	5.5	10.0	140												140	0
8-01-79	D	C*	6.0	15.0	60												60	121
8-01-79	N	C	0.5	14.0													0	0
8-01-79	N	C	2.0	10.4	32												32	0
8-01-79	N	C	4.0	10.4	225												225	0
8-01-79	N	C	5.5	9.9	231												231	0
8-01-79	N	C*	6.0	12.4													0	64
8-01-79	D	D	0.5	14.1	273												273	0
8-01-79	D	D	2.5	9.0	478												478	0
8-01-79	D	D	4.5	9.0	133												133	0
8-01-79	D	D	6.5	9.0	121												121	0
8-01-79	D	D	8.5	8.0	28												28	0
8-01-79	D	D*	9.0	15.5													0	86
8-01-79	N	D	0.5	12.9	686												686	0
8-01-79	N	D	2.5	9.0	348												348	0
8-01-79	N	D	4.5	9.0	277												277	0
8-01-79	N	D	6.5	9.0	30	15											45	0
8-01-79	N	D	8.5	8.0	14												14	0
8-01-79	N	D*	9.0	11.6	44												44	0

Appendix 11. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
8-01-79	D	E	0.5	14.9	230												230	0
8-01-79	D	E	3.0	12.2	221	34		17									272	0
8-01-79	D	E	6.0	12.2	136												136	0
8-01-79	D	E	9.0	12.2	18												18	0
8-01-79	D	E	11.0	6.2													0	0
8-01-79	D	E*	12.0	12.0									36				36	0
8-01-79	N	E	0.5	13.3	216												216	0
8-01-79	N	E	3.0	11.5	358												358	0
8-01-79	N	E	6.0	11.5	171												171	0
8-01-79	N	E	9.0	11.5													0	0
8-01-79	N	E	11.0	9.2	17												17	0
8-01-79	N	E*	12.0	8.6	22	22											44	0
8-01-79	D	F	0.5	14.4	61		31										92	0
8-01-79	D	F	4.5	10.8	544												544	0
8-01-79	D	F	8.5	10.8	30												30	0
8-01-79	D	F	11.5	10.8													0	0
8-01-79	D	F	14.0	5.8													0	0
8-01-79	D	F*	15.0	15.0													0	109
8-01-79	N	F	0.5	13.8	242												242	0
8-01-79	N	F	4.5	7.7	198												198	0
8-01-79	N	F	8.5	7.7				15			15						30	15
8-01-79	N	F	11.5	7.7													0	0
8-01-79	N	F	14.0	4.6													0	0
8-01-79	N	F*	15.0	6.9	50												50	50
8-20-79	D	P	0.5	15.5													0	0
8-20-79	D	P	0.5	15.5	303												303	0
8-21-79	D	P*	1.0	16.5	7764	68										XL: 68	7900	0
8-21-79	N	P	0.5	14.8	411												411	0
8-21-79	N	P	0.5	14.8													0	0
8-22-79	N	P*	1.0	15.5	1782	242											2024	0
8-21-79	D	A	0.5	16.3	3160												3160	0
8-21-79	D	A*	1.5	15.8	865												865	0
8-21-79	N	A	0.5	15.5	5986												5986	0

Appendix 11. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
8-21-79	D	B	0.5	16.0													0	0
8-21-79	D	B	2.5	15.5	4837												4837	0
8-21-79	D	B*	3.0	15.5	330												330	0
8-22-79	N	B	0.5	15.5	1755												1755	0
8-22-79	N	B	2.5	15.2	4492												4492	0
8-22-79	N	B*	3.0	15.2	579												579	0
8-20-79	D	C	0.5	14.0													0	0
8-20-79	D	C	2.0	13.5	14												14	0
8-20-79	D	C	4.0	13.5	289												289	0
8-20-79	D	C	5.5	13.5	391												391	0
8-21-79	D	C*	6.0	15.0	58												58	0
8-20-79	N	C	0.5	14.0	254				14								268	0
8-20-79	N	C	2.0	14.0	222												222	0
8-20-79	N	C	4.0	14.0	314												314	0
8-20-79	N	C	5.5	14.0	293												293	0
8-22-79	N	C*	6.0	15.0	260												260	0
8-20-79	D	D	0.5	14.5													0	0
8-20-79	D	D	2.5	14.0	19												19	0
8-20-79	D	D	4.5	14.0	1525											XC: 13	1538	0
8-20-79	D	D	6.5	14.0	1534												1534	0
8-20-79	D	D	8.5	14.0	613												613	0
8-21-79	D	D*	9.0	15.1	163												163	0
8-20-79	N	D	0.5	14.5	819												819	0
8-20-79	N	D	2.5	14.0	794												794	0
8-20-79	N	D	4.5	14.0	234												234	0
8-20-79	N	D	6.5	14.0	352	13											365	0
8-20-79	N	D	8.5	14.0	505												505	0
8-21-79	N	D*	9.0	15.1	254												254	0
8-20-79	D	E	0.5	13.5													0	0
8-20-79	D	E	3.0	14.0	299												299	0
8-20-79	D	E	6.0	14.0	1014												1014	0
8-20-79	D	E	9.0	14.0	597			14									611	0
8-20-79	D	E	11.0	14.0	516												516	0
8-21-79	D	E*	12.0	14.5	62												62	0
8-20-79	N	E	0.5	14.0	846												846	0
8-20-79	N	E	3.0	14.0	108												108	0
8-20-79	N	E	6.0	14.0	359	12											371	0
8-20-79	N	E	9.0	14.0	808												808	0
8-20-79	N	E	11.0	14.0	535												535	0
8-21-79	N	E*	12.0	15.0	148										187	NS: 37	372	0

Appendix 11. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
8-20-79	D	F	0.5	14.5													0	0
8-20-79	D	F	4.5	13.5	440				18								458	0
8-20-79	D	F	8.5	13.5	70												70	0
8-20-79	D	F	11.5	13.5	181												181	0
8-20-79	D	F	14.0	13.0	313												313	0
8-21-79	D	F*	15.0	14.5	35												35	0
8-20-79	N	F	0.5	14.5	274												274	0
8-20-79	N	F	4.5	14.0	147											NS: 12	159	0
8-20-79	N	F	8.5	14.0	435												435	0
8-20-79	N	F	11.5	14.0	640												640	0
8-20-79	N	F	14.0	13.5	95												95	0
8-21-79	N	F*	15.0	15.5	281												281	0
9-19-79	D	P	0.5	14.5													0	0
9-19-79	D	P	0.5	14.5													0	0
9-19-79	D	P*	1.0	14.0	385												385	0
9-19-79	N	P	0.5	14.8													0	0
9-19-79	N	P	0.5	14.8	246												246	0
9-19-79	N	P*	1.0	14.0	124											NS: 31	155	0
9-19-79	D	A	0.5	15.0													0	0
9-19-79	D	A*	1.5	12.5	396												396	36
9-19-79	N	A	0.5	14.0	20												20	0
9-19-79	N	A*	1.5	14.0	56												56	0
9-19-79	D	B	0.5	13.3													0	0
9-19-79	D	B	2.5	12.0	48												48	0
9-19-79	D	B*	3.0	12.0	35												35	0
9-19-79	N	B	0.5	14.7	104												104	0
9-19-79	N	B	2.5	14.0	29												29	0
9-19-79	N	B*	3.0	13.0													0	0
9-17-79	D	C	0.5	14.4													0	0
9-17-79	D	C	2.0	14.0	15												15	0
9-17-79	D	C	4.0	14.0	15												15	0
9-17-79	D	C	5.5	13.8	135												135	0
9-19-79	D	C*	6.0	12.0	42												42	0
9-17-79	N	C	0.5	14.8	396				15								411	0
9-17-79	N	C	2.0	14.2	551												551	0
9-17-79	N	C	4.0	14.2	187												187	0
9-17-79	N	C	5.5	14.2	34												34	0
9-19-79	N	C*	6.0	9.0													0	0

Appendix 11. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	SM	YP	XP	GS	SS	CP	TP	BR	JD	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
9-17-79	D	D	0.5	14.1													0	0
9-17-79	D	D	2.5	13.1													0	0
9-17-79	D	D	4.5	13.1	91												91	0
9-17-79	D	D	6.5	13.1	15												15	0
9-17-79	D	D	8.5	12.8													0	0
9-19-79	D	D*	9.0	11.7													0	0
9-17-79	N	D	0.5	14.0	108												108	0
9-17-79	N	D	2.5	12.0	18												18	0
9-17-79	N	D	4.5	12.0	19												19	0
9-17-79	N	D	6.5	12.0													0	0
9-17-79	N	D	8.5	11.5	28												28	0
9-19-79	N	D*	9.0	9.0	36								36		36		108	0
9-17-79	D	E	0.5	14.5													0	0
9-17-79	D	E	3.0	12.2	80												80	0
9-17-79	D	E	6.0	12.2													0	0
9-17-79	D	E	9.0	12.2													0	0
9-17-79	D	E	11.0	12.0													0	0
9-19-79	D	E*	12.0	10.7													0	0
9-17-79	N	E	0.5	13.6	28												28	0
9-17-79	N	E	3.0	11.4	18												18	0
9-17-79	N	E	6.0	11.4	19												19	0
9-17-79	N	E	9.0	11.4													0	0
9-17-79	N	E	11.0	11.4													0	0
9-19-79	N	E*	12.0	12.0													0	0
9-17-79	D	F	0.5	13.8													0	0
9-17-79	D	F	4.5	11.1													0	0
9-17-79	D	F	8.5	11.1	36												36	0
9-17-79	D	F	11.5	11.1													0	0
9-17-79	D	F	14.0	11.1													0	0
9-19-79	D	F*	15.0	10.0													0	0
9-17-79	N	F	0.5	14.0	198												198	0
9-17-79	N	F	4.5	11.0	36												36	0
9-17-79	N	F	8.5	11.0													0	0
9-17-79	N	F	11.5	11.0	14												14	0
9-17-79	N	F	14.0	11.0													0	0
9-19-79	N	F*	15.0	10.8													0	0

APPENDIX 12

Appendix 12. Number of fish larvae and eggs per 1000 m^3 in Pigeon Lake (Fig. 2) near the J.H. Campbell Plant, eastern Lake Michigan, April to September 1979. D = day, N = night. See Table 42 for species code identification.

DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	AL	SP	YP	XL	PM	CP	XP	ES	BM	GS	XM	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
4-18-79	D	S	0.5	8.5													0	0
4-18-79	D	S	0.5	8.5													0	0
4-20-79	N	S	0.5	9.3													0	0
4-20-79	N	S	0.5	9.3													0	0
4-18-79	D	V	0.5	8.5													0	0
4-18-79	D	V	0.5	8.5													0	0
4-19-79	N	V	0.5	11.7													0	0
4-19-79	N	V	0.5	11.7													0	0
4-18-79	D	M	0.5	7.8													0	0
4-18-79	D	M	2.5	7.3													0	0
4-18-79	D	M	4.5	7.0													0	0
4-20-79	N	M	0.5	9.5													0	0
4-20-79	N	M	2.5	7.0													0	0
4-20-79	N	M	4.5	6.5													0	0
4-18-79	D	X	0.5	10.6													0	0
4-20-79	N	X	0.5	11.0													0	0
5-14-79	D	S	0.5	13.0		1058	529									XC:1058	2645	0
5-14-79	D	S	0.5	13.0			709										709	0
5-14-79	N	S	0.5	12.6		222	666									XS: 111	999	111
5-14-79	N	S	0.5	12.6			969					138				XX: 138	1245	0
5-14-79	D	V	0.5	14.9			6762										6762	0
5-14-79	D	V	0.5	14.9			497										497	0
5-14-79	N	V	0.5	14.7			8071									SM: 375	8446	0
5-14-79	N	V	0.5	14.7			4549		162		162						4873	0
5-15-79	D	M	0.5	13.1			1355		26		26						1407	0
5-15-79	D	M	2.5	12.6			783		80							SM: 53	916	0
5-15-79	D	M	4.5	12.6			726									SM: 64	790	0
5-16-79	N	M	0.5	13.8			60		152					30			242	0
5-16-79	N	M	2.5	12.5			210		174							SM: 104	488	0
5-16-79	N	M	4.5	12.3			182				35					SM: 35	252	0

Appendix 12. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	YP	XL	PM	CP	XP	ES	BM	GS	XM	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
									NUMBER OF LARVAE PER 1000 M³									
5-15-79	D	X	0.5	14.3			4115		209					34			4358	0
5-16-79	N	X	0.5	15.0			41873		1944	41				124		JD: 82 GL: 41	44105	0
6-05-79	D	S	0.5	15.0													0	341
6-05-79	D	S	0.5	15.0		341											341	0
6-04-79	N	S	0.5	13.0												JD: 533	533	0
6-04-79	N	S	0.5	13.0												JD: 512	512	0
6-05-79	D	V	0.5	17.5			404	404									808	0
6-05-79	D	V	0.5	17.5			808		808								1616	0
6-04-79	N	V	0.5	16.5			7740		430	430							8600	0
6-04-79	N	V	0.5	16.5			1428										1428	0
6-04-79	D	M	0.5	15.5													0	46
6-04-79	D	M	2.5	14.5												SM: 60	60	0
6-05-79	D	M	4.5	14.0	73												73	0
6-05-79	N	M	0.5	14.5			50										50	0
6-05-79	N	M	2.5	14.0													0	0
6-05-79	N	M	4.5	13.5												SM: 77	77	0
6-05-79	D	X	0.5	18.0			41										41	0
6-05-79	N	X	0.5	17.0		108	216		54					54		SM: 54	486	0
6-20-79	D	S	0.5	14.4		1268											1268	1904
6-20-79	D	S	0.5	14.4													0	1881
6-20-79	N	S	0.5	14.6		12454	336										12790	71380
6-20-79	N	S	0.5	14.6	336	9424											9760	2356
6-20-79	D	V	0.5	17.5			354										354	0
6-20-79	D	V	0.5	17.5			380	380									760	1142
6-20-79	N	V	0.5	16.3			930			1860					310		3100	930
6-20-79	N	V	0.5	16.3		3720	620										4340	0
6-20-79	D	M	0.5	15.0													0	0
6-20-79	D	M	2.5	14.5	33		33										66	0
6-20-79	D	M	4.5	14.2	54	17	18									SM: 17	106	0
6-20-79	N	M	0.5	14.2	60	90	30										180	0
6-20-79	N	M	2.5	14.2	324	72				35						SM: 71	502	0
6-20-79	N	M	4.5	14.0	294	98	32										424	0

Appendix 12. Continued.

DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	AL	SP	YP	XL	PM	CP	XP	ES	BM	GS	XM	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
6-20-79	D	X	0.5	17.0													0	1545
6-20-79	N	X	0.5	16.3	24	24				96							144	0
7-03-79	D	S	0.5	16.4													0	919
7-03-79	D	S	0.5	16.4													0	5333
7-04-79	N	S	0.5	15.0													0	416
7-04-79	N	S	0.5	15.0													0	512
7-03-79	D	V	0.5	21.2					476								476	3333
7-03-79	D	V	0.5	21.2													0	0
7-04-79	N	V	0.5	18.0													0	4444
7-04-79	N	V	0.5	18.0													0	888
7-03-79	D	M	0.5	16.5	22												22	22
7-03-79	D	M	2.5	14.0													0	0
7-03-79	D	M	4.5	12.0													0	0
7-03-79	N	M	0.5	15.0	110	22											132	0
7-04-79	N	M	2.5	12.5	86												86	261
7-04-79	N	M	4.5	11.8	139	139											278	558
7-03-79	D	X	0.5	21.5	114			38									152	153
7-04-79	N	X	0.5	15.0				30									30	12534
7-16-79	D	S	0.5	22.3	1441	360				1441							3242	3243
7-16-79	D	S	0.5	22.3	2881	1080				720							4681	2162
7-19-79	N	S	0.5	13.0		1512											1512	17929
7-19-79	N	S	0.5	13.0		2328											2328	0
7-16-79	D	V	0.5	23.7	775												775	0
7-16-79	D	V	0.5	23.7													0	0
7-19-79	N	V	0.5	18.0	582			1455					1746				3783	0
7-19-79	N	V	0.5	18.0		292		2923		584			292			JD: 292	4383	292
7-16-79	D	M	0.5	22.5	444	29				29							502	0
7-16-79	D	M	2.5	22.0	4253					20	102						4375	0
7-16-79	D	M	4.5	22.0	3361												3361	0
7-16-79	N	M	0.5	22.5	2030	592				28	56						2706	11525
7-16-79	N	M	2.5	22.2	12387	941					179	107			71	SM: 35	13720	724
7-16-79	N	M	4.5	22.0	4816	624				71							5511	0

Appendix 12. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	NUMBER OF LARVAE PER 1000 M³ AL	SP	YP	XL	PM	CP	XP	ES	BM	GS	XM	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
7-16-79	D	X	0.5	23.4													0	0
7-16-79	N	X	0.5	23.4	891	104				79		26			26	SM: 26	1152	0
8-02-79	D	S	0.5	17.5	30982					360							31342	360
8-02-79	D	S	0.5	17.5	1585	1189						1190					3964	0
8-02-79	N	S	0.5	17.5		68394		289		869		579					70131	289
8-02-79	N	S	0.5	17.5	578	42596				869							44043	0
8-02-79	D	V	0.5	23.6	370			2222									2592	0
8-02-79	D	V	0.5	23.6				370									370	0
8-02-79	N	V	0.5	19.5	341	1023		1367									2731	0
8-02-79	N	V	0.5	19.5				4786									4786	0
8-02-79	D	M	0.5	16.5													0	573
8-02-79	D	M	2.5	14.4	133	22											155	113
8-02-79	D	M	4.5	13.9	23	46											69	93
8-02-79	N	M	0.5	17.0	478	131	26										635	0
8-02-79	N	M	2.5	15.5	640	175						29					844	0
8-02-79	N	M	4.5	15.0	722	453											1175	0
8-02-79	D	X	0.5	22.6	31												31	0
8-01-79	N	X	0.5	19.5	4129	672		1570		96	96	32					6595	0
8-20-79	D	S	0.5	15.5													0	0
8-20-79	D	S	0.5	15.5													0	0
8-21-79	N	S	0.5	15.2	666	3330											3996	0
8-21-79	N	S	0.5	15.2		3636											3636	0
8-20-79	D	V	0.5	18.5													0	0
8-20-79	D	V	0.5	18.5													0	0
8-21-79	N	V	0.5	17.5	447										447		894	0
8-21-79	N	V	0.5	17.5		354											354	0
8-23-79	D	M	0.5	16.5	1550												1550	0
8-23-79	D	M	2.5	15.8	2102												2102	0
8-23-79	D	M	4.5	15.5	3551												3551	0
8-24-79	N	M	0.5	16.5	224	32								32			288	0
8-24-79	N	M	2.5	16.0	2731												2731	0
8-24-79	N	M	4.5	16.0	686												686	0

Appendix 12. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SP	YP	XL	PM	CP	XP	ES	BM	GS	XM	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³
					NUMBER OF LARVAE PER 1000 M³													
8-23-79	D	X	0.5	19.3	33												33	0
8-24-79	N	X	0.5	16.5	99												99	0
9-17-79	D	S	0.5	12.5													0	0
9-17-79	D	S	0.5	12.5													0	0
9-17-79	N	S	0.5	13.0		1818							2424				4242	0
9-17-79	N	S	0.5	13.0		1050						350	350				1750	0
9-17-79	D	V	0.5	18.2													0	0
9-17-79	D	V	0.5	18.2													0	0
9-17-79	N	V	0.5	15.9													0	0
9-17-79	N	V	0.5	15.9													0	0
9-17-79	D	M	0.5	12.7													0	0
9-17-79	D	M	2.5	11.7													0	0
9-17-79	D	M	4.5	11.3													0	0
9-17-79	N	M	0.5	10.5	147												147	0
9-17-79	N	M	2.5	10.1	91												91	0
9-17-79	N	M	4.5	12.5	38												88	0
9-17-79	D	X	0.5	16.7													0	0
9-17-79	N	X	0.5	17.0													0	0

APPENDIX 13

Appendix 13. Number of fish larvae and eggs per 1000 m^3 for intake canal station Z (Fig. 2) near the J.H. Campbell Plant, eastern Lake Michigan, April to September 1979. D = day, N = night. See Table 42 for species code identification.

DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	AL	YP	CP	SP	PM	SM	XL	GS	XP	JD	SS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
4-18-79	D	Z	0.5	7.2													0	0
4-18-79	D	Z	2.5	7.2													0	0
4-19-79	N	Z	0.5	5.5													0	0
4-19-79	N	Z	2.5	7.0													0	0
5-15-79	D	Z	0.5	13.6		892			23								915	0
5-15-79	D	Z	2.5	12.8		2960			56	113							3129	0
5-16-79	N	Z	0.5	12.6		1151			692	46				46			1935	0
5-16-79	N	Z	2.5	12.6		625	41		454	82		41					1243	0
6-04-79	D	Z	0.5	13.2													0	0
6-04-79	D	Z	2.5	13.7													0	0
6-05-79	N	Z	0.5	14.5					51								51	51
6-05-79	N	Z	2.5	13.0		52				52							104	0
6-20-79	D	Z	0.5	15.5													0	0
6-20-79	D	Z	2.5	15.0	26					26							52	53
6-20-79	N	Z	0.5	15.5	61			336					30				427	0
6-20-79	N	Z	2.5	15.0	54	82		165									301	0
7-03-79	D	Z	0.5	18.5	299												299	226
7-03-79	D	Z	2.5	15.0													0	0
7-03-79	N	Z	0.5	14.5	66						33						99	1024
7-03-79	N	Z	2.5	14.0	135												135	3224
7-16-79	D	Z	0.5	22.0	1477			56									1533	74
7-16-79	D	Z	2.5	22.0	5339												5339	0
7-16-79	N	Z	0.5	22.1	433		501				21						955	65
7-16-79	N	Z	2.5	22.1	3218		1577	179									4974	289
8-02-79	D	Z	0.5	17.6				29									29	0
8-02-79	D	Z	2.5	15.5	148												148	0
8-01-79	N	Z	0.5	17.0	454			399									853	0
8-01-79	N	Z	2.5	16.0	1541			444									1985	40

Appendix 13. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AI	YP	CP	SP	PM	SM	XL	GS	XP	JD	SS	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3
					NUMBER OF LARVAE PER 1000 M^3													
8-23-79	D	Z	0.5	17.5	189												189	0
8-23-79	D	Z	2.5	17.0	1016												1016	0
8-22-79	N	Z	0.5	15.7	427												427	0
8-22-79	N	Z	2.5	15.7	2066												2066	0
9-17-79	D	Z	0.5	12.8													0	0
9-17-79	D	Z	2.5	12.5	21												21	0
9-17-79	N	Z	0.5	14.2	26												26	0
9-17-79	N	Z	2.5	13.7	29												29	0

APPENDIX 14

Appendix 14. A weekly summary of fish larvae and eggs entrained by the J. H. Campbell Plant from January through December 1979. This summary includes average number of fish larvae and eggs entrained per diel period. See Table 42 for species code identification.

DATE	DIEL PERIOD	INTAKE TEMP. C	AL	YP	PM	CP	SP	XP	SM	XM	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³	WATER VOLUME PUMPED IN 1000 M³	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
			NUMBER OF LARVAE PER 1000 M³													
1-10-79	DAWN	4.2										0	0	68	0	0
1-10-79	DAY	5.0										0	0	245	0	0
1-09-79	DUSK	4.5										0	0	68	0	0
1-09-79	NIGHT	4.8										0	0	435	0	0
	TOTAL													816	0	0
1-30-79	DAWN	3.0										0	3461	68	0	235348
1-30-79	DAY	2.2										0	560	267	0	149520
1-29-79	DUSK	2.8										0	3	68	0	204
1-29-79	NIGHT	2.2										0	356	413	0	147028
	TOTAL													816	0	532100
2-06-79	DAWN	4.8										0	3576	68	0	243168
2-06-79	DAY	5.0										0	35	274	0	9590
2-05-79	DUSK	4.0										0	901	68	0	61268
2-05-79	NIGHT	3.8										0	297	407	0	120879
	TOTAL													817	0	434905
3-01-79	DAWN	4.5										0	0	68	0	0
3-01-79	DAY	4.5									FS: 7	7	0	304	2128	0
2-28-79	DUSK	4.2									FS: 8	8	0	68	544	0
2-28-79	NIGHT	4.2									FS: 3	3	0	376	1128	0
	TOTAL													816	3800	0
3-06-79	DAWN	1.8										0	0	68	0	0
3-06-79	DAY	2.0									FS: 3	3	0	321	963	0
3-05-79	DUSK	2.0									FS: 3	3	0	68	204	0
3-05-79	NIGHT	2.0									FS: 7	7	0	360	2520	0
	TOTAL													817	3687	0
3-22-79	DAWN	3.0										0	0	136	0	0
3-22-79	DAY	3.5									FS: 2	2	0	693	1386	0
3-21-79	DUSK	4.0										0	0	136	0	0
3-21-79	NIGHT	3.0										0	0	669	0	0
	TOTAL													1634	1386	0
3-29-79	DAWN	3.5										0	0	136	0	0
3-29-79	DAY	3.2										0	0	709	0	0
3-28-79	DUSK	3.0										0	0	136	0	0
3-28-79	NIGHT	4.0									FS: 2	2	0	652	1304	0
	TOTAL													1633	1304	0

Appendix 14. Continued.

DATE	DIEL PERIOD	INTAKE TEMP. C	AL	YP	FM	CP	SP	XP	SM	XM	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³	WATER VOLUME PUMPED IN 1000 M³	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
			NUMBER OF LARVAE PER 1000 M³													
4-08-79	DAWN	2.5										0	0	136	0	0
4-08-79	DAY	2.5										0	0	742	0	0
4-07-79	DUSK	3.0										0	0	136	0	0
4-07-79	NIGHT	3.0									FS: 5	5	0	619	3095	0
	TOTAL													1633	3095	0
4-12-79	DAWN	5.0									FS: 6	6	0	136	816	0
4-12-79	DAY	4.5										0	0	752	0	0
4-11-79	DUSK	5.0										0	0	136	0	0
4-11-79	NIGHT	4.5									FS: 6					
											TP: 5	11	0	609	6699	0
	TOTAL													1633	7515	0
4-18-79	DAWN	7.0										0	3	81	0	243
4-18-79	DAY	7.5						1				1	0	475	475	0
4-18-79	DUSK	7.0									TP: 1					
											XC: 1	2	0	81	162	0
4-19-79	NIGHT	7.0									TP: 1	1	1	342	342	342
	TOTAL													979	979	585
4-27-79	DAWN	9.0		28								28	0	81	2268	0
4-26-79	DAY	9.0		2								2	0	483	966	0
4-26-79	DUSK	9.0		2								2	0	81	162	0
4-26-79	NIGHT	9.0		13								13	0	334	4342	0
	TOTAL													979	7738	0
5-03-79	DAWN	12.5		279				21			BR: 1	301	5	81	24381	405
5-02-79	DAY	10.0		283								283	3	501	141783	1503
5-02-79	DUSK	10.0		51			2	27			XS: 1	81	1498	81	6561	121338
5-03-79	NIGHT	8.5		89				16			XS: 5	110	2	315	34650	630
	TOTAL													978	207375	123876
5-17-79	DAWN	12.0	3	523	222	249		104	138			1239	12	81	100359	972
5-17-79	DAY	13.0		1329	815	119	5	218	31			2517	9	517	1301289	4653
5-16-79	DUSK	13.0		743	163	180		184	28	1	XX: 1					
											XS: 3	1303	146	81	105543	11826
5-17-79	NIGHT	13.0		625	221	358		190	83		TP: 1	1478	318	300	443400	95400
	TOTAL													979	1950591	112851

Appendix 14. Continued.

DATE	DIEL PERIOD	INTAKE TEMP. C	AL	YP	PM	CP	SP	XP	SM	XM	MISC.		TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³	WATER VOLUME PUMPED IN 1000 M³	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
			NUMBER OF LARVAE PER 1000 M³														
5-24-79	DAWN	9.0		492	52	203		103	99				949	10	81	76869	810
5-24-79	DAY	10.0		239	54	12		41	100		GS:	4	450	9	530	238500	4770
5-23-79	DUSK	10.0		322	48	93	1	44	46		FS:	1	555	1	81	44955	81
5-24-79	NIGHT	9.5		143	36	352		39	90				660	245	286	188760	70070
	TOTAL														978	549084	75731
5-31-79	DAWN	9.4		121	25	17		14	5				182	384	81	14742	31104
5-30-79	DAY	10.0		37	17			5	5		TP:	1	65	229	536	34840	122744
5-30-79	DUSK	10.0		28	16	6		11	15		GS:	1	77	214	81	6237	17334
5-31-79	NIGHT	9.7		46	22	67		6	11		TP:	3	155	16847	281	43555	4734007
	TOTAL														979	99374	4905189
6-06-79	DAWN	14.0		4			4	6	13	6	BM:	4	37	1406	81	2997	113886
6-04-79	DAY	13.5		2	3	3	9	1	5				23	25	539	12397	13475
6-04-79	DUSK	13.5	14	5	5	17	32	8					81	11845	81	6561	959445
6-05-79	NIGHT	14.0	5	5	5	21	1	5	5	3	TP:	7	57	40387	277	15789	11187199
	TOTAL														978	37744	12274005
6-13-79	DAWN	16.5	2	3		16	1	20	13	16			71	199	81	5751	16119
6-12-79	DAY	16.5	10		2	9	2	20	9	2	GS:	1	55	136	545	29975	74120
6-12-79	DUSK	16.5	5	3	1	10	7	10		3			39	2725	81	3159	220725
6-13-79	NIGHT	12.5	3	17	5	14	17	7		3	XE:	2					
											SS:	2	73	20613	271	18970	5586123
	TOTAL														978	57855	5897087
6-19-79	DAWN	14.5	12	7	1	7	91	17	42	13	BM:	1	191	3775	81	15471	305775
6-19-79	DAY	16.0	3			1	3	14	5				26	215	546	14196	117390
6-19-79	DUSK	15.5	2			16	17	7	10	2	BM:	2					
											ES:	8	64	3515	81	5184	284715
6-19-79	NIGHT	15.0	25		1	14	216	5	75				336	22222	270	90720	5999940
	TOTAL														978	125571	6707820
6-27-79	DAWN	12.0	4				2	11	16				33	1040	81	2673	84240
6-2o-79	DAY	13.0	3	3	5	5		8	8				32	569	546	17472	310674
6-26-79	DUSK	12.8	14			5		15	6		GS:	1	41	2000	81	3321	162000
6-27-79	NIGHT	13.7	3			37		16		4	TP:	1	61	49725	270	16470	13425750
	TOTAL														978	39936	13982664

Appendix 14. Continued.

DATE	DIEL PERIOD	INTAKE TEMP. C	AL	YP	PM	CP	SP	XP	SM	XM	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³	WATER VOLUME PUMPED IN 1000 M³	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
			NUMBER OF LARVAE PER 1000 M³													
7-04-79	DAWN	14.5	2				2					4	1844	81	324	149364
7-04-79	DAY	12.8	1		2				4			7	639	543	3801	346977
7-04-79	DUSK	12.0		4			1		7			12	11448	81	972	927288
7-04-79	NIGHT	14.9		1			1		10		ES: 1	13	16651	273	3549	4545723
	TOTAL													978	8646	5969352
7-12-79	DAWN	16.8	64	11	6		10		4		SV: 5 XL: 5	105	777571	81	8505	62983251
7-12-79	DAY	18.5	27	14		6						47	4748	539	25333	2559172
7-11-79	DUSK	17.0	65	131		20	15	9	14			254	154244	81	20574	12493764
7-12-79	NIGHT	16.0	68	96	4	55	110	18		6		357	1286648	277	98889	356401496
	TOTAL													978	153301	434437683
7-17-79	DAWN	19.0	448			335	883	106		38	BM: 3 ES: 41	1854	86	136	252144	11696
7-16-79	DAY	21.0	227			144	97	4				472	516	893	421496	460788
7-16-79	DUSK	21.0	1217			352	77					1646	502	136	223856	68272
7-17-79	NIGHT	21.0	1479	2		1936	534	65		2	ES: 5	4023	4365	468	1882764	2042820
	TOTAL													1633	2780260	2583576
7-24-79	DAWN	20.0	421			9	74	12		5	XX: 5	526	174	136	71536	23664
7-24-79	DAY	20.0	176				32	6		3		217	73	872	189224	63656
7-24-79	DUSK	20.0	318			9	24				JD: 2	353	537	136	48008	73032
7-25-79	NIGHT	20.0	451		25	33	70	15			ES: 2	596	8907	490	292040	4364430
	TOTAL													1634	600808	4524782
8-02-79	DAWN	15.5	134			21	275	5			XL: 3	438	0	136	59568	0
8-01-79	DAY	15.8	221		2	2	35	2			ES: 7	269	0	849	228381	0
8-01-79	DUSK	16.0	174			6	247	2				429	0	136	58344	0
8-02-79	NIGHT	15.0	163			31	342	19		19	XL: 5	579	2	513	297027	1026
	TOTAL													1634	643320	1026
8-07-79	DAWN	20.5	104	4	1	2	488	8		1	TP: 2 XL: 1	611	5	136	83096	680
8-07-79	DAY	21.0	46				16					62	0	835	51770	0
8-07-79	DUSK	21.4	161			4	78				ES: 4	247	0	136	33592	0
8-08-79	NIGHT	21.0	335			2	265			4	ES: 16 XL: 5 JD: 5	632	2	526	332432	1052
	TOTAL													1633	500890	1732

Appendix 14. Continued.

DATE	DIEL PERIOD	INTAKE TEMP. C	AL	YP	PM	CP	SP	XP	SM	XM	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³	WATER VOLUME PUMPED IN 1000 M³	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
			NUMBER OF LARVAE PER 1000 M³													
8-10-79	DAWN	20.5	1309			2	165				JD: 2	1478	0	136	201008	0
8-10-79	DAY	21.7	286				5	5		2		298	0	835	248830	0
8-09-79	DUSK	21.0	198				19			12	ES: 10					
											XL: 4	243	0	136	33048	0
8-10-79	NIGHT	20.5	497	3	3	8	59	10		10	TP: 4					
											ES: 42					
											XL: 10					
											JD: 3	649	0	526	341374	0
	TOTAL													1633	824260	0
8-14-79	DAWN	12.0	54				103	6			ES: 33					
											XL: 6	202	0	136	27472	0
8-13-79	DAY	10.0	29				22		2		TP: 2					
											ES: 2	57	0	820	46740	0
8-13-79	DUSK	11.0	51				69				ES: 5	125	0	136	17000	0
8-13-79	NIGHT	12.0	92		2	2	151	21		56	ES: 26					
											XL: 2	352	0	541	190432	0
	TOTAL													1633	281644	0
8-16-79	DAWN	11.3	87				270				ES: 34	391	0	136	53176	0
8-16-79	DAY	11.5	12				33			2		47	0	820	38540	0
8-15-79	DUSK	12.0	93				49	14	4	3	ES: 2	165	0	136	22440	0
8-15-79	NIGHT	12.2	66				179	5			ES: 5					
											XL: 15	270	0	541	146070	0
	TOTAL													1633	260226	0
8-21-79	DAWN	14.8	196				2					198	0	136	26928	0
8-21-79	DAY	18.0	120				2				ES: 3	125	2	805	100625	1610
8-20-79	DUSK	15.0	140								ES: 2	142	0	136	19312	0
8-21-79	NIGHT	15.0	82							3	TP: 2	87	2685	556	48372	1492860
	TOTAL													1633	195237	1494470
8-23-79	DAY	18.0	294				8					302	0	371	112042	0
8-23-79	NIGHT	17.6	1458				13					1471	0	282	414822	0
	TOTAL													653	526864	0
8-28-79	DAWN	19.0	184									184	0	54	9936	0
8-28-79	DAY	19.4	136									136	0	310	42160	0
8-28-79	DUSK	19.4	548									548	0	54	29592	0
8-28-79	NIGHT	19.0	799									799	0	234	186966	0
	TOTAL													652	268654	0

Appendix 14. Continued.

DATE	DIEL PERIOD	INTAKE TEMP. C	AL	YP	PM	CP	SP	XP	SM	XM	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M³	TOTAL NUMBER OF EGGS PER 1000 M³	WATER VOLUME PUMPED IN 1000 M³	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
			NUMBER OF LARVAE PER 1000 M³													
8-29-79	DAY	20.0	58									58	0	365	21170	0
8-30-79	NIGHT	19.8	277									277	0	288	79776	0
	TOTAL													653	100946	0
9-06-79	DAWN	20.0	26									26	0	136	3536	0
9-05-79	DAY	21.0	132									132	0	743	98076	0
9-05-79	DUSK	22.0	137									137	0	136	18632	0
9-05-79	NIGHT	21.0	48									48	0	618	29664	0
	TOTAL													1633	149908	0
9-13-79	DAWN	18.0	42									42	0	136	5712	0
9-12-79	DAY	18.0	29									29	0	728	21112	0
9-12-79	DUSK	18.5	50								GS: 8	58	0	136	7888	0
9-12-79	NIGHT	18.5	44					6			GS: 3					
											ES: 2	55	0	633	34815	0
	TOTAL													1633	69527	0
9-18-79	DAWN	14.7	18									18	0	136	2448	0
9-18-79	DAY	12.0	2									2	0	710	1420	0
9-18-79	DUSK	15.5	13									13	0	136	1768	0
9-17-79	NIGHT	14.2	65								TP: 5					
											JD: 2	72	0	652	46944	0
	TOTAL													1634	52580	0
9-27-79	DAWN	11.5	2									2	0	54	108	0
9-26-79	DAY	11.5	30									30	0	271	8130	0
9-26-79	DUSK	12.0	39									39	0	54	2106	0
9-26-79	NIGHT	11.8	35						2			37	0	273	10101	0
	TOTAL													652	20445	0
10-02-79	DAWN	14.0										0	0	54	0	0
10-02-79	DAY	17.0	6									6	0	264	1584	0
10-01-79	DUSK	18.0	7									7	0	54	378	0
10-02-79	NIGHT	13.5	38									38	0	280	10640	0
	TOTAL													652	12602	0
10-17-79	DAWN	13.0	3									3	0	54	162	0
10-16-79	DAY	10.0	8									8	0	244	1952	0
10-16-79	DUSK	13.0	20									20	0	54	1080	0
10-17-79	NIGHT	13.5	9				2					11	0	300	3300	0
	TOTAL													652	6494	0

Appendix 14. Continued.

DATE	DIEL PERIOD	INTAKE TEMP. C	AL	YP	FM	CP	SP	XP	SM	XM	MISC.	TOTAL NUMBER OF LARVAE PER 1000 M^3	TOTAL NUMBER OF EGGS PER 1000 M^3	WATER VOLUME PUMPED IN 1000 M^3	TOTAL NUMBER OF LARVAE ENTRAINED	TOTAL NUMBER OF EGGS ENTRAINED
			NUMBER OF LARVAE PER 1000 M^3													
11-07-79	DAWN	9.5	4									4	0	136	544	0
11-07-79	DAY	10.0	2									2	0	550	1100	0
11-06-79	DUSK	10.0	3									3	0	136	408	0
11-07-79	NIGHT	10.0	8									8	0	812	6496	0
	TOTAL													1634	8548	0
12-04-79	DAWN	3.5										0	0	136	0	0
12-04-79	DAY	4.5										0	0	485	0	0
12-04-79	DUSK	4.0										0	0	136	0	0
12-04-79	NIGHT	5.0										0	0	876	0	0
	TOTAL													1633	0	0
12-28-79	DAWN	1.9										0	0	68	0	0
12-28-79	DAY	2.1										0	0	238	0	0
12-27-79	DUSK	2.5										0	0	68	0	0
12-28-79	NIGHT	2.3										0	0	442	0	0
	TOTAL													816	0	0

APPENDIX 15

Appendix 15. Number of fish fry per 1000 m^3 caught during larvae sampling in Lake Michigan, Pigeon Lake and the intake canal (Figs. 1 and 2) near the J.H. Campbell Plant, eastern Lake Michigan, April to September 1979. D = day, N = night. See Table 42 for species code identification.

					NUMBER OF FRY PER 1000 M³													TOTAL NUMBER OF FRY PER 1000 M³
DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	AL	SM	SP	YP	JD	ES	TP	BM	XC	BG	SS	PP	MISC.	
9-17-79	N	Z	0.5	14.2	53													53
5-14-79	N	S	0.5	12.6						222								222
5-14-79	N	S	0.5	12.6						1944								1944
5-14-79	N	V	0.5	14.7								187						187
5-15-79	N	V	0.5	14.7				162										162
6-20-79	N	V	0.5	16.3				930										930
7-19-79	N	V	0.5	18.0				291										291
8-02-79	N	S	0.5	17.5					289									289
8-02-79	N	V	0.5	19.5				1025										1025
8-02-79	N	V	0.5	19.5				683										683
8-02-79	N	M	0.5	17.0	26													26
8-02-79	N	M	2.5	15.5	29													29
8-01-79	N	X	0.5	19.5			32	32										64
8-21-79	N	S	0.5	15.2													YB: 666	666
8-21-79	N	V	0.5	17.5	354													354
8-24-79	N	M	0.5	16.5	32													32
8-24-79	N	M	2.5	16.5		61												61
8-24-79	N	M	4.5	16.0	37	37												74
8-24-79	N	X	0.5	16.5	33													33
9-17-79	D	S	0.5	12.5						634								634
9-17-79	N	V	0.5	15.9										849				849
9-17-79	N	V	0.5	15.9				2020						2020				4040
9-17-79	D	M	4.5	11.3	41													41
9-17-79	N	M	0.5	10.5	49													49
9-17-79	N	M	2.5	10.1	88	88												176
9-17-79	N	M	4.5	12.5	43													43
9-17-79	N	X	0.5	17.0	130													130
4-17-79	N	P	0.5	8.0												333		333

Appendix 15. Continued.

DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	AL	SM	SP	YP	JD	ES	TP	BM	XC	BG	SS	PP	MISC.	TOTAL NUMBER OF FRY PER 1000 M³
					NUMBER OF FRY PER 1000 M³													
4-17-79	N	L	5.5	3.0		16												16
5-16-79	N	A*	1.5	13.0					39									39
5-16-79	N	Q*	1.0	12.8			49											49
5-16-79	N	J*	3.0	12.8		47	94											141
5-16-79	N	L*	6.0	11.8					43									43
6-04-79	N	F*	15.0	9.8											29			29
6-04-79	N	J*	3.0	12.5					55									55
6-04-79	N	I*	6.0	11.5							34							34
6-19-79	N	I*	1.5	12.7							56							56
6-19-79	N	L*	6.0	12.7							63							63
6-19-79	N	C	9.0	16.0		16												16
7-02-79	N	D	0.5	9.0		12												12
7-02-79	D	Q*	1.0	11.0			77											77
7-03-79	N	Q	0.5	9.6													CH: 162	162
7-03-79	N	R*	1.0	10.0			113											113
7-03-79	N	N*	9.0	5.9					40									40
7-03-79	N	O*	12.0	5.8			28				57							85
7-18-79	N	B*	3.0	7.3		75												75
7-18-79	D	C	5.5	5.0		12												12
7-18-79	N	C	2.0	4.0		62												62
7-18-79	N	C	4.0	4.0		16												16
7-18-79	N	C	5.5	4.0		16												16
7-18-79	N	D*	9.0	4.0					40									40
7-17-79	D	R	0.5	14.5		257												257
7-17-79	D	R*	1.0	14.5		52	52											104
7-17-79	N	R	0.5	13.5		351												351
7-17-79	D	I*	1.5	11.5		263												263
7-18-79	N	I	0.5	11.7		68												68
7-19-79	N	L	2.0	11.0		13												13
7-18-79	N	L*	6.0	6.5							74							74
7-19-79	N	O	6.0	6.0		12												12

Appendix 15. Continued.

DATE	DIEL PERIOD	STA- TION	DEPTH (M)	TEMP. C	AL	SM	SP	YP	JD	ES	TP	BM	XC	BG	SS	PP	MISC.	TOTAL NUMBER OF FRY PER 1000 M³
					NUMBER OF FRY PER 1000 M³													
8-01-79	N	P*	1.0	15.2	23													23
8-01-79	N	A*	1.5	14.3		33												33
8-01-79	N	C*	6.0	12.4		32												32
8-01-79	D	D*	9.0	15.5		43												43
8-01-79	N	D*	9.0	11.6		22												22
8-01-79	N	E	9.0	11.5		14												14
8-01-79	N	E	11.0	9.2		17												17
8-01-79	D	Q*	1.0	13.9		259												259
8-01-79	N	Q	0.5	14.7		206												206
8-01-79	N	Q	0.5	14.7	155	620												775
8-01-79	N	Q*	1.0	14.7		1226												1226
8-01-79	N	R*	1.0	15.5		72												72
8-01-79	D	J*	3.0	12.5		277												277
8-02-79	D	L	0.5	16.0		17												17
8-01-79	D	L*	6.0	10.9		106												106
8-02-79	N	L	2.0	11.4		16												16
8-01-79	N	L*	6.0	13.5		50												50
8-01-79	D	N*	9.0	15.3		36												36
8-02-79	N	N	8.5	8.5		15												15
8-01-79	D	O*	12.0	14.2		98												98
8-02-79	N	O	9.0	13.6	16													16
8-02-79	N	O	11.0	6.2		14												14
8-02-79	N	W	0.5	16.0	14													14
8-02-79	N	W	4.5	12.5		15												15
8-02-79	N	W	8.5	12.5		47												47
8-02-79	N	W	11.5	12.5		57												57
8-02-79	N	W	14.0	7.5		54												54
8-21-79	D	P*	1.0	16.5	137													137
8-21-79	N	P	0.5	14.8		411												411
8-21-79	N	P	0.5	14.8	404													404
8-22-79	N	P*	1.0	15.5	40													40
8-21-79	N	A	0.5	15.5	53													53
8-22-79	N	B	0.5	15.5	54													54
8-22-79	N	B	2.5	15.5	130													130
8-22-79	N	B*	3.0	15.2		103												103
8-20-79	D	C	0.5	14.0		19												19
8-20-79	D	C	5.5	13.5		27												27
8-20-79	N	C	2.0	14.0	18													18
8-20-79	N	C	5.5	14.0	17													17
8-22-79	N	C*	6.0	15.0		262												262

Appendix 15. Continued.

DATE	DIEL PERIOD	STA- TION	DEPTH (M)	TEMP. C	AL	SM	SP	YP	JD	ES	TP	BM	XC	BG	SS	PP	MISC.	TOTAL NUMBER OF FRY PER 1000 M³
					NUMBER OF FRY PER 1000 M³													
8-20-79	D	D	2.5	14.0	19													19
8-20-79	D	D	4.5	14.0		13												13
8-20-79	N	D	2.5	14.0	11													11
8-20-79	N	D	4.5	14.0	53													53
8-20-79	N	D	6.5	14.0	78	13												91
8-20-79	N	D	8.5	14.0	142	71												213
8-21-79	N	D*	9.0	15.1	85	342												427
8-20-79	D	E	3.0	14.0		14												14
8-20-79	D	E	6.0	14.0		20												20
8-20-79	N	E	0.5	14.0	99	14												113
8-20-79	N	E	3.0	14.0	286	17												303
8-20-79	N	E	6.0	14.0	174	12												186
8-20-79	N	E	9.0	14.0	221	170												391
8-20-79	N	E	11.0	14.0	129	155												284
8-21-79	N	E*	12.0	15.0		261												261
8-20-79	N	F	0.5	14.5	39	19												58
8-20-79	N	F	4.5	14.0	64	25												89
8-20-79	N	F	8.5	14.0	87													87
8-20-79	N	F	11.5	14.0	103	181												284
8-21-79	N	F*	15.0	15.5		126												126
8-22-79	N	Q*	1.0	15.2	86	43												129
8-20-79	D	R	0.5	14.5	136													136
8-20-79	N	R	0.5	16.0	366													366
8-22-79	N	R*	1.0	15.5	270	231	38											539
8-21-79	D	I	0.5	16.5		26												26
8-21-79	D	I*	1.5	16.0		248												248
8-22-79	N	I	0.5	15.8	337	42												379
8-22-79	N	I*	1.5	15.3	75	37												112
8-22-79	N	J	0.5	15.7	125	41												166
8-22-79	N	J	2.5	15.0	233	87												320
8-22-79	N	J*	3.0	15.0		562												562

Appendix 15. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SM	SP	YP	JD	ES	TP	BM	XC	BG	SS	PP	MISC.	TOTAL NUMBER OF FRY PER 1000 M³
					NUMBER OF FRY PER 1000 M³													
8-21-79	D	L	0.5	16.0		56												56
8-21-79	D	L	2.0	15.2		36												36
8-21-79	D	L*	6.0	14.8		61												61
8-21-79	N	L	0.5	16.0	36	12												48
8-21-79	N	L	2.0	15.0	49													49
8-22-79	N	L*	6.0	15.2		379												379
8-21-79	D	N*	9.0	15.2		16												16
8-21-79	N	N	0.5	15.1	13	13												26
8-21-79	N	N	2.5	14.3	13	13												26
8-21-79	N	N	4.5	14.3	26													26
8-21-79	N	N	8.5	14.3	33	16												49
8-22-79	N	N*	9.0	15.0		616												616
8-21-79	D	O*	12.0	14.5		52												52
8-21-79	N	O	0.5	15.0	25	12												37
8-21-79	N	O	3.0	14.8	93	13												106
8-20-79	N	O	6.0	14.8	33	11												44
8-21-79	N	O	11.0	14.5		23												23
8-22-79	N	O*	12.0	15.0		211												211
8-21-79	D	W	8.5	14.5		11												11
8-21-79	N	W	0.5	15.0	303													303
8-21-79	N	W	4.5	15.0	58													58
8-21-79	N	W	8.5	15.0	73	58												131
8-21-79	N	W	11.5	15.4	58	46												104
8-21-79	N	W	14.0	14.6	67	81												148
8-22-79	N	W*	15.0	15.5		147												147
9-19-79	N	P*	1.0	14.0			31											31
9-19-79	N	B*	3.0	13.0		29												29
9-17-79	N	C	0.5	14.8	15	15												30
9-17-79	N	C	2.0	14.2		31												31
9-17-79	N	D	6.5	12.0	17													17
9-19-79	N	D*	9.0	9.0		36												36
9-17-79	N	E	3.0	11.4		18												18
9-19-79	N	E*	12.0	12.0		21												21
9-17-79	N	F	14.0	11.0	14													14
9-19-79	N	F*	15.0	10.8		30												30

Appendix 15. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SM	SP	YP	JD	ES	TP	BM	XC	BG	SS	PP	MISC.	TOTAL NUMBER OF FRY PER 1000 M^3
					NUMBER OF FRY PER 1000 M^3													
9-19-79	N	Q*	1.0	14.0			699											699
9-19-79	N	R*	1.0	13.7		70												70
9-19-79	N	L*	6.0	11.1		48												48
9-19-79	N	N	8.5	12.5		14												14
9-17-79	N	O	9.0	13.6		13												13
9-19-79	N	W	11.5	13.1		51												51
9-19-79	N	W	14.0	10.5		39							13					52

APPENDIX 16

Appendix 16. Number of fish fry per 1000 m^3 entrained by the J. H. Campbell Plant, eastern Lake Michigan, January to December 1979. W = dawn, D = day, K = dusk and N = night. See Table 42 for species code identification.

					NUMBER OF FRY PER 1000 M³													TOTAL NUMBER OF
DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SM	SP	YP	JD	ES	TP	XP	XC	BG	SS	PP	MISC.	FRY PER 1000 M³
3-06-79	D	SD	0.5	2.0				15										15
4-12-79	W	SD	0.5	5.0		27												27
4-18-79	K	SD	0.5	7.0		6												6
5-02-79	N	SD	0.5	8.5						5								5
6-27-79	N	SD	0.5	13.7		7												7
7-04-79	N	SD	0.5	14.5			10											10
7-12-79	N	SD	0.5	16.0							17							17
7-16-79	K	SD	0.5	21.0		16												16
7-24-79	K	SD	0.5	20.0		9												9
8-02-79	W	SD	0.5	15.5		10												10
8-02-79	W	SD	0.5	15.5		19												19
8-01-79	D	SD	0.5	15.8	11													11
8-02-79	N	SD	0.5	15.0		20												20
8-07-79	W	SD	0.5	20.5		25												25
8-08-79	N	SD	0.5	21.0		20												20
8-08-79	N	SD	0.5	21.0		22												22
8-08-79	N	SD	0.5	21.0		9												9
8-10-79	W	SD	0.5	20.5		10												10
8-10-79	W	SD	0.5	20.5	10													10
8-10-79	D	SD	0.5	21.7	10													10
8-10-79	D	SD	0.5	21.7	10													10
8-09-79	K	SD	0.5	21.0	10													10
8-09-79	K	SD	0.5	21.0		9												9
8-09-79	K	SD	0.5	21.0	24	24												48
8-09-79	K	SD	0.5	21.0		9												9
8-10-79	N	SD	0.5	20.5	93	93												186
8-10-79	N	SD	0.5	20.5	256	29												285
8-10-79	N	SD	0.5	20.5	358	111												469
8-10-79	N	SD	0.5	20.5	182	34												216

Appendix 16. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SM	SP	YP	JD	ES	TP	XP	XC	BG	SS	PP	MISC.	TOTAL NUMBER OF FRY PER 1000 M³
					NUMBER OF FRY PER 1000 M³													
8-14-79	W	SD	0.5	12.0	29													29
8-14-79	W	SD	0.5	12.0	28													28
8-14-79	W	SD	0.5	12.0	278	106						13						397
8-14-79	W	SD	0.5	12.0	137	55												192
8-13-79	D	SD	0.5	10.0		26												26
8-13-79	D	SD	0.5	10.0		23												23
8-13-79	D	SD	0.5	10.0	140													140
8-13-79	D	SD	0.5	10.0	113	11												124
8-13-79	K	SD	0.5	11.0	18	27												45
8-13-79	K	SD	0.5	11.0	135	72												207
8-13-79	K	SD	0.5	11.0	102	143						10						255
8-13-79	K	SD	0.5	11.0	70	111												181
8-13-79	N	SD	0.5	12.0	147	124												271
8-13-79	N	SD	0.5	12.0	162	216						10						388
8-13-79	N	SD	0.5	12.0	31	104												135
8-13-79	N	SD	0.5	12.0	59	128						29						216
8-16-79	W	SD	0.5	11.3	51	238												289
8-16-79	W	SD	0.5	11.3	10	75												85
8-16-79	W	SD	0.5	11.3	12	12												24
8-16-79	W	SD	0.5	11.3	63	126												189
8-16-79	D	SD	0.5	11.5		89												89
8-16-79	D	SD	0.5	11.5		161												161
8-16-79	D	SD	0.5	11.5		47												47
8-16-79	D	SD	0.5	11.5		109												109
8-15-79	K	SD	0.5	12.0	33	50												83
8-15-79	K	SD	0.5	12.0	24	48						12						84
8-15-79	K	SD	0.5	12.0	77	253												330
8-15-79	K	SD	0.5	12.0	40	111												151
8-16-79	N	SD	0.5	12.2	33	77												110
8-15-79	N	SD	0.5	12.2	81	142												223
8-16-79	N	SD	0.5	12.2	30	20												50
8-15-79	N	SD	0.5	12.2	106	127												233
8-21-79	W	SD	0.5	14.8	62	78												140
8-21-79	W	SD	0.5	14.8		10												10
8-21-79	W	SD	0.5	14.8	34	11						11						56
8-21-79	W	SD	0.5	14.8	10	10												20
8-21-79	D	SD	0.5	18.0	54	21												75
8-21-79	D	SD	0.5	18.0	55	69												124
8-21-79	D	SD	0.5	18.0	28	14												42

Appendix 16. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SM	SP	YP	JD	ES	TP	XP	XC	BG	SS	PP	MISC.	TOTAL NUMBER OF FRY PER 1000 M³
					NUMBER OF FRY PER 1000 M³													
8-20-79	K	SD	0.5	15.0	85	32												117
8-20-79	K	SD	0.5	15.0	103	57						11						171
8-20-79	K	SD	0.5	15.0	54	73												127
8-20-79	K	SD	0.5	15.0	31	103												134
8-20-79	N	SD	0.5	15.0	22	56												78
8-20-79	N	SD	0.5	15.0	12	48												60
8-21-79	N	SD	0.5	15.0	60	48												108
8-21-79	N	SD	0.5	15.0	12	49												61
8-23-79	D	SD	0.5	18.0	34													34
8-23-79	D	SD	0.5	18.0	16	16												32
8-23-79	D	SD	0.5	18.0	17													17
8-23-79	D	SD	0.5	18.0		34												34
8-23-79	N	SD	0.5	17.6	31	31												62
8-23-79	N	SD	0.5	17.6		53												53
8-23-79	N	SD	0.5	17.6		48												48
8-23-79	N	SD	0.5	17.6		40												40
8-28-79	W	SD	0.5	19.0	15													15
8-28-79	W	SD	0.5	19.0	36													36
8-28-79	W	SD	0.5	19.0	15													15
8-28-79	W	SD	0.5	19.0	8													8
8-28-79	K	SD	0.5	19.4	109													109
8-28-79	K	SD	0.5	19.4	18													18
8-28-79	K	SD	0.5	19.4	121													121
8-28-79	K	SD	0.5	19.4	19													19
8-27-79	N	SD	0.5	19.0	210													210
8-28-79	N	SD	0.5	19.0	319													319
8-28-79	N	SD	0.5	19.0	257													257
8-28-79	N	SD	0.5	19.0	264													264
8-29-79	D	SD	0.5	20.0		16												16
8-29-79	D	SD	0.5	20.0	17													17
8-30-79	N	SD	0.5	19.8	101													101
8-30-79	N	SD	0.5	19.8	97													97
8-30-79	N	SD	0.5	19.8	18	18												36
8-30-79	N	SD	0.5	19.8	110													110

Appendix 16. Continued.

DATE	DIEL PERIOD	STATION	DEPTH (M)	TEMP. C	AL	SM	SP	YP	JD	ES	TP	XP	XC	BG	SS	PP	MISC.	TOTAL NUMBER OF FRY PER 1000 M³
					NUMBER OF FRY PER 1000 M³													
9-06-79	W	SD	0.5	20.0	490													490
9-06-79	W	SD	0.5	20.0	504													504
9-06-79	W	SD	0.5	20.0	351													351
9-06-79	W	SD	0.5	20.0	262													262
9-05-79	D	SD	0.5	21.0	37													37
9-05-79	D	SD	0.5	21.0	26													26
9-05-79	D	SD	0.5	21.0	12													12
9-05-79	D	SD	0.5	21.0	42													42
9-05-79	K	SD	0.5	22.0	101													101
9-05-79	K	SD	0.5	22.0	205													205
9-05-79	K	SD	0.5	22.0	168													168
9-05-79	K	SD	0.5	22.0	216													216
9-05-79	N	SD	0.5	21.0	271													271
9-05-79	N	SD	0.5	21.0	197													197
9-05-79	N	SD	0.5	21.0	126													126
9-05-79	N	SD	0.5	21.0	165													165
9-13-79	W	SD	0.5	18.0	215	10												225
9-13-79	W	SD	0.5	18.0	211	11												222
9-13-79	W	SD	0.5	18.0	194	9												203
9-13-79	W	SD	0.5	18.0	454													454
9-12-79	D	SD	0.5	18.0	32													32
9-12-79	D	SD	0.5	18.0	40													40
9-12-79	D	SD	0.5	18.0	27	13												40
9-12-79	D	SD	0.5	18.0	59													59
9-12-79	K	SD	0.5	18.5	117													117
9-12-79	K	SD	0.5	18.5	47													47
9-12-79	K	SD	0.5	18.5	55													55
9-12-79	K	SD	0.5	18.5	100	11												111
9-12-79	N	SD	0.5	18.5	165	43												208
9-12-79	N	SD	0.5	18.5	79	22												101
9-12-79	N	SD	0.5	18.5	104	52												156
9-12-79	N	SD	0.5	18.5	70	8												78
9-18-79	W	SD	0.5	14.7	69	23												92
9-18-79	W	SD	0.5	14.7	63	21												84
9-18-79	W	SD	0.5	14.7	54													54
9-18-79	W	SD	0.5	14.7	91	10												101
9-18-79	D	SD	0.5	12.0	96	10												106
9-18-79	D	SD	0.5	12.0	21	10												31
9-18-79	D	SD	0.5	12.0	36	36												72
9-18-79	D	SD	0.5	12.0	10							10						20

Appendix 16. Continued.

DATE	DIEL PERICD	STA- TION	DEPTH (M)	TEMP. C	AL	SM	SP	YP	JD	ES	TP	XP	XC	BG	SS	PP	MISC.	TOTAL NUMBER OF FRY PER 1000 M³
					NUMBER OF FRY PER 1000 M³													
9-18-79	K	SD	0.5	15.5	11	55												66
9-18-79	K	SD	0.5	15.5	43	10						10						63
9-18-79	K	SD	0.5	15.5	48	12												60
9-18-79	K	SD	0.5	15.5	48	9												57
9-17-79	N	SD	0.5	14.2	11	11												22
9-17-79	N	SD	0.5	14.2	73													73
9-17-79	N	SD	0.5	14.2	74	21												95
9-17-79	N	SD	0.5	14.2	113	68												181
9-27-79	W	SD	0.5	11.5	12	12												24
9-27-79	W	SD	0.5	11.5	9	9												18
9-26-79	D	SD	0.5	11.5	21													21
9-26-79	D	SD	0.5	11.5	72													72
9-26-79	D	SD	0.5	11.5	11													11
9-26-79	D	SD	0.5	11.5	42													42
9-26-79	N	SD	0.5	11.8	32	10												42
9-26-79	N	SD	0.5	11.8	31	10												41
9-26-79	N	SD	0.5	11.8	21													21
10-02-79	W	SD	0.5	14.0		8												8
10-02-79	W	SD	0.5	14.0	34													34
10-02-79	W	SD	0.5	14.0	12	24												36
10-02-79	D	SD	0.5	17.0	11													11
10-01-79	K	SD	0.5	18.0	10													10
10-01-79	K	SD	0.5	18.0	21													21
10-01-79	N	SD	0.5	13.5		9												9
10-01-79	N	SD	0.5	13.5	9	19												28
10-02-79	N	SD	0.5	13.5		26												26
10-02-79	N	SD	0.5	13.5	31	21												52
10-17-79	W	SD	0.5	13.0	9	9												18
10-17-79	W	SD	0.5	13.0	23													23
10-17-79	W	SD	0.5	13.0	25													25
10-16-79	D	SD	0.5	10.0	13	13												26
10-16-79	D	SD	0.5	10.0	11	11												22
10-16-79	D	SD	0.5	10.0		24												24
10-16-79	K	SD	0.5	13.0	32													32
10-16-79	K	SD	0.5	13.0		10												10
10-16-79	K	SD	0.5	13.0	30	10												40
10-16-79	K	SD	0.5	13.0	40													40
10-17-79	N	SD	0.5	13.5	25	12												37
10-17-79	N	SD	0.5	13.5	23	11												34
10-17-79	N	SD	0.5	13.5		13												13
10-17-79	N	SD	0.5	13.5	44	22												66

Appendix 16. Continued.

DATE	DIEL PERIOD	STA-TION	DEPTH (M)	TEMP. C	AL	SM	SP	YP	JD	ES	TP	XP	XC	BG	SS	PP	MISC.	TOTAL NUMBER OF FRY PER 1000 M^3
					NUMBER OF FRY PER 1000 M^3													
11-07-79	W	SD	0.5	9.5	77		11											88
11-07-79	W	SD	0.5	9.5	35													35
11-07-79	W	SD	0.5	9.5	20													20
11-07-79	W	SD	0.5	9.5	65													65
11-07-79	D	SD	0.5	10.0	10													10
11-06-79	K	SD	0.5	10.0	25	25												50
11-06-79	K	SD	0.5	10.0	66	13												79
11-06-79	K	SD	0.5	10.0	12													12
11-07-79	N	SD	0.5	10.0	22													22
12-04-79	K	SD	0.5	4.0			14											14